BULLETINS
OF
AMERICAN PALEONTOLOGY
Vol. 9

No. 39

The Miocene of Northern Costa Rica

WITH NOTES ON ITS GENERAL STRATIGRAPHIC RELATIONS

BY

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Part 1

(*Pp. 1-168, April 21*)

1922

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DEDICATED

TO THE

MUSEUM OF COSTA RICA

THE MIOCENE OF NORTHERN COSTA RICA

WITH NOTES ON ITS GENERAL STRATIGRAPHIC RELATIONS

BY

A. A. OLSSON

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PRELIMINARY REMARKS

The fossil collections and field information, on which this monograph is based, resulted from over two years of field work by the writer in Panama and Costa Rica. The writer's thanks are due to the Costa Rica Oil Corporation for permission to publish; and he is most grateful for assistance, and encouragement received in the course of this work from Drs. A. C. Veatch and D. F. MacDonald of the Sinclair Exploration Company, to the Officials of the National Museum of Costa Rica and Professor J. Fidel Tristan of San Jose'.

The collections were studied in the Paleontogic Laboratory of Cornell University, the facilities of which, Professor G. D. Harris, most generously placed at my disposal.

Cornell University,
January, 1922. A. A. OLSSON

GENERAL STRATIGRAPHY OF NORTHERN COSTA RICA

The northern or Atlantic slope of Costa Rica, the so-called "Tierra Caliente" is largely composed of Tertiary sedimentary rocks, which except for some folding, dip away from the slopes of the Cordillera Central towards the sea. To the east, this sedimentary belt may be traced into the Province of Bocas del Toro of western Panama, where its upper and highly fossiliferous beds are well developed and exposed on the islands of the Chiriqui Lagoon. This Tertiary sedimentary belt ends some 35 to 40 miles east of the city of Bocas del Toro. The Miocene sedimentary rocks of Batun and of the northern Canal Zone form a small independent unit, which begins about 30 miles west of Colon and ends close to the eastern limits of the Canal Zone.

In a general way, the stratigraphic succession in northern Costa Rica is as follows:

Pleistocene Slightly elevated coastal swamps, with deposits of cross-bedded sands, clay-marls etc.

Pliocene Certain reef-limestones composed of coral and hydrozoa remains; also marls, blue lignitiferous clays, blue coarse sandstones, and a predominating hard conglomerate, composed of large boulders of igneous rocks (the so-called boulder-clays of several writers on Costa Rican Geology).

Miocene The *Gatun Stage* or *Formation*. Coral-reef limestones, (near the coast), marls, more generally a blue or blue-black sandstone, dark colored shales, sandy and impure limestones, lignites and conglomerates. Generally very fossiliferous.

The *Uscari Stage* or *Formation*. Usually dark-colored shales but with some sandstones, limestones and conglomerates. The smaller types of foraminfera are usually quite abundant, and are associated with fish-scales, and small echinoid spines, with mollusks generally rare.

Oligocene Sandstones, shales and a complex of hard, often semicrystalline limestones which pass through all possible gradations to coarse arkosic sandstones. The most abundant and characteristic fossils are the Orbitoidal foraminifera (*Lepidocyclina*). The

age of these beds probably ranges from Lower to Upper Oligocene.

THE COSTA RICAN MIOCENE

An important part of the stratigraphic succession of northern Costa Rica is composed of rocks of Miocene age, whose thickness varies according to locality and completeness of section, from a few hundred to several thousands of feet. They are divisible into two stages or formations by an unconformity or disconformity of greater or less degree. In their natural order of sequence, these divisions of the Costa Rican Miocene are:

Gatun Stage or Formation: Middle and Upper Miocene

Uscari Stage or Formation: Lower Miocene

THE USCARI STAGE

The Uscari stage or formation derives its name from Uscari creek in the Talamanca valley of eastern Costa Rica. It consists principally of soft, dark-colored shales and because of their slight resistance to denundation, their outcrop frequently forms wide valleys and interior basins. These shales were deposited in quiet and moderately deep water, and their fauna is largely composed of the smaller types of foraminifera, such as *Globigerina*, *Textularia*, *Lagena*, *Nodosaria* and *Miliola*, but the large Orbitoidal *Lepidocyclinæ*, abundant in the underlying Oligocene, are absent. Mollusks are very uncommon in this formation. The small fauna described by Gabb from Sapote, Costa Rica, belongs to the lower part of the Uscari formation.

THE GATUN STAGE

The upper division of the Costa Rican Miocene is equivalent in part to the Gatun formation of the Canal Zone. The typical Gatun, so named from its well-known exposures at Gatun and in which a part of the Panama Canal and the locks at Gatun were excavated, lies in an independent sedimentary basin across the

northern end of the Canal Zone and in the adjacent parts of the Province of Colon. There the Gatun formation consists of blue sandstones, dark-colored shales, fuller's earth beds etc., generally less than 500 feet thick. Many of its beds are very fossiliferous. The mollusks of the Gatun stage of Panama have been studied by Dall, Toula, Brown, Pilsbry and Cossmann.

In Costa Rica, the Gatun is very much thicker than in the Canal Zone and represents a longer depositional period. Paleontologically, the Gatun of the Canal Zone, seems to represent only the lower part of the formation as developed in Costa Rica. It is largely of sandy character, more resistant to denudation than the Uscari shales and gives rise to a more rugged and hilly topography. Although typically sandy, it also contains locally shales, lignites, conglomerates and coralline limestones. In some localities the limy members are of major importance. The formation is characterized by marked lateral variation in which respect it differs strongly from the much more uniform shales of the Uscari stage. This feature of lateral variation gives rise to two important phases: that of the more typical Gatun, in which the beds are largely sandy in character, with some lignitic and coarsely conglomeritic members, and carrying the usual near shore Gatun fauna; and the coralline phase, in which the beds are more marine, with coralline limestone and richly fossiliferous marls perdominating, and with no lignitic beds.

Along the inner margin of the Miocene belt, the Gatun belongs to the first and more typical phase; while the coralline type is more common along the coastal zone, as at Port Limon and Bocas del Toro. Coralline rocks may occur at any horizon in the Gatun succession or it may locally be composed of massive coral-reef limestones. Such is the case in the Limon Peninsula, and such coralline limestones, by most observers, have been regarded as of Pliocene or even of more recent age. At Limon,

this confusion has partly arisen from the fact that these Miocene limestones are overlain by the second series, of Pliocene age, which partly yielded the large fauna described by Gabb, published shortly after his death in 1881. Dall later contributed to the discussion of this fauna. The truly Miocene limestones of Limon may be seen in good exposures along the sea-front west of the city. There they are massive in character, hard and recrystallized to the extent that all traces of organic remains have usually been obliterated or rendered uncertain of determination. However, some sandy or marly beds are occasionally found intercalated in these coralline limestones, and from these layers we have collected a large fauna of unquestionable Miocene affinities, correlating closely in age with the Bowden beds of Jamaica.

The fauna of the Costa Rican Gatun is largely molluscan. The following paleontological study records 334 species. Future collecting will doubtless greatly add to this list, as several species common it the Canal Zone, still remains undiscovered in Costa Rica. The smaller types of foraminifera abound in the more shaly phases of the formation, as well as several species of echinoids, belonging to the genera *Clypeaster* and *Encope*. Corals of simple and compound types occur principally in the coralline phase.

The Uscari - Gatun Unconformity

At the close of Uscari time the Miocene sea was withdraw from the greater part of Costa Rica, but during the Gatun, it returned. These conditions are indicated by a stratigraphic break between the two stages, a complete change in their lithologic composition, the occurrence of Gatun beds in areas which had received no deposition during Uscari times and a change in their respective faunas. Although the full stratigraphic details of this important subject cannot be presented at the present time, attention is called to it, as the outstanding feature of the Miocene stratigraphy of Panama and Costa Rica; and because of its bearing on correlation.

In many parts of northern Costa Rica, the Gatun stage carries at its base a thick and persistent conglomerate, formed of coarse cobbles of igneous rocks, or of finer pebbles with alternating layers of sandstone. This conglomerate generally rests disconformably on the Uscari, but in some cases is unconformable on these or older rocks. This basal conglomerate is generally firmly cemented and because of its superior hardness, may become an important ridge former. It marks the site of high water-falls along many streams. Fossils of common Gatun types are abundant at many localities in this basal conglomerate.

Gatun rocks are frequently found in areas which contain no Uscari beds. In such cases, the Gatun is found resting, with strong unconformity, on older rocks. This condition is seen in the Canal Zone and along the borders of the sedimentary belt of the western Panama. It indicates, either a complete erosion of the Uscari shales during the Uscari-Gatun interval or, what is more likely, a greater transgression of the Gatun sea. This uncomformable relation of the Gatun upon older sedimentary beds may be seen in the Chagres Spillway in the Canal Zone, where the underlying rocks are sandstones, probably equivalent to the Mt. Lirio of Lower Oligocene age. In the Chiriqui Lagoon country, of western Panama, the base of the Gatun is frequently a coral-reef limestone, which rests directly upon the older and more disturbed rocks.

* * * * *

The present systematic study enumerates 334 species of molluska of which the majority belong to the Gatun stage. A few of these species have not been found in Costa Rica or western Panama, but are common in the Canal Zone, and are included here for the sake of comparison with Costa Rican species. To these we may add the 18 species described by Gabb from Sapote, Costa Rica, but not included in our collections and the following species listed below from the Canal Zone. This brings

the total known Miocene fauna of Panama and Costa Rica to 396 species.

Volvulella micratracta Brown and Pilsbry
Ringicula hypograpta Brown and Pilsbry
Conus haytensis Sowerby
Conus domingensis Sowerby
Cruns consobrinus Sowerby
Conus æmulator Brown and Pilsbry
Drillia vaningeni Brown and Pilsbry
Drillia gatunensis Toula
Drillia fusinus Brown and Pilsbry
Drillia Zooki Brown and Pilsbry
Drillia enneacyma Brown and Pilsbry
Cythara heptagona Gabb
Marginella gatunensis Brown and Pilsbry
Anachis fugax Brown and Pilsbry
Murex polynematicus Brown and Pilsbry
Murex gatunsis Brown and Pilsbry
Typhis Gabbi Brown and Pilsbry
Malea camura Guppy
Cyprea Henekini Sowerby, var.
Bittium nugatorium Brown and Pilsbry
Natica bolus Brown and Pilsbry
Natica canalizonalis Brown and Pilsbry
Sigaretus gatunensis Toula
Sigaretus (Eunaticina) Gabbi Brown and Pilsbry
Cheilea princetonia Brown and Pilsbry
Nucula (Acila) isthmica Brown and Pilsbry
Pecten effosus Brown and Pilsbry
Pecten operculariformis Toula
Pecten reliquus Brown and Pilsbry
Amusium Toulæ Prown and Pilsbry
Ostrea gatunensis Brown and Pilsbry
Cardium durum Brown and Pilsbry
Cardium gatunensis Dall
Tellina æquiterminata Brown and Pilsbry
Corbula gatunensis Toula
Corbula sphenis Dall
Corbula sericea Dall
Solecurtus strigillatus Linné

Chione tegulum Brown and Pilsbry
Pitaria cora Brown and Pilsbry
Dosinia delicatissima Brown and Pilsbry
Petricola millestriata Brown and Pilsbry
Cyclinella gatunensis Dall
Thracia gatunensis Toula

The Uscari fauna is still poorly known, but it includes several very distinctive species of which the following are most important:
Amusinm Lyonii Gabb
Arca dariensis Brown and Pilsbry also Lower Gatun
Clementia dariena Conrad also Lower Gatun
Cancellaria (*Aphera*) *islacolonis* Maury
Neverita nereidis Maury
Sconsia cocleana Olsson
Scaphella costaricana Olsson
Ptychosalpinx? dentalis Olsson
Dentalium uscarianum Olsson

The Gatun is the great fossil bearing formation of northern Costa Rica and Panama, and is characterized by a rich and highly diversified fauna. This fauna at the present numbers nearly 400 species, but additional collecting will doubtless add considerably to this number. As we have already noted the Gatun beds present two important facies, the sandy and highly clastic phase of the typical Gatun, and the deeper water type, illustrated by the coralline limestones and their associated marls. These lithological types have their own more or less peculiar and distinctive faunas.

The typical Gatun is the more common phase and is characterized by a molluscan fauna of heavy, thick-shelled species of littoral forms. In Costa Rica, the following are the most common and characteristic:

Arca MacDonaldi Dall
Arca Pittieri Dall
Pecten levicostatus Toula
Marginella MacDonaldi Dall
Voluta Alfaroi Dall
Strombus pugiloidis Guppy

Cardium stiriatum Brown, Pilsbry
Chione Rowelli Olsson
Chione mactropsis Conrad
Dosinia acetabulum Conrad
Conus molis Brown and Pilsbry
Stormbus gatunensis Toula
Natica Guppyana Toula
Turritella altilira Conrad and its varieties

The coralline phase is developed at several localities along the coast, most important of which are Port Limon and Bocas del Toro. Here the coralline limestones and associated marls form the greater part of the Gatun section, but coralline rocks may occur, interbedded with typical Gatun rocks, at any stratigraphical level.

These coralline limestones were formed, mainly as barrier reefs some little distance from the old Gatun shore-line. Naturally they offered very different habitat conditions from those of the typical near-shore and often lacustrine Gatun. Hence we find a fauna of deeper-water affinities with Pleurotomids and thin-shelled Cones, as the most important and characteristic element. In localities where these coralline rocks are exclusively developed, this fauna bears very little relation to the typical Gatun fauna, although the two are contemporaneous. The following are species of the coralline phase:

Pecten coralliphila Olsson
Antigona Harrisiana Olsson
Gafrarium limonensis Olsson
Large number of Pleurotomids
Conus planiliratus Sowerby
Conus limonensis Olsson
Conus stenostomus Sowerby
Turritella exoleta Linné var. *limonensis* Olsson
Mitra Alamagrensis var. *coralliphila* Olsson
Mitra poas Olsson
Marginella avena Valennencies
Olivella limonensis Olsson
Phos elegans, variety *limonensis* Olsson
Siliquaria modesta Dall, *limonensis* var. Olsson

About 13 per cent. of the Gatun fauna is identical or closely related to the recent species, the majority of which are found living along the present Caribbean coast, certain others only on the Pacific side in the Panama Province and a few common to both. This large percentage of recent forms corresponds closely

with that characterizing the Chesapeake Miocene fauna of the eastern United States and shows their close agreement in age. The recent species and their closely related forms in the Gatun fauna are as follows:

Arca occidentalis Phil. West Indian
Arca umbonata Lamarck West Indian
Arca candida Gmelin West Indian
Arca auriculata Lamarck West Indlan
Ostrea megodon Hanley Pacific
Anomia simplex d'Orb. West Indian
Phacoides radians Conrad var. *medioamericanus* Olsson West Indian
Phacoides trisulcatus Conrad West Indian
Glycymeris castaneus Lamarck West Indian
Glycymeris decussatus Linné West Indian
Divaricella quadrisulcata d'Orb. West Indian
Cardium medium Linné West Indian
Cardium spinosum var. *Turtoni* Dall East Atlantic
Cardium serratum Linné West Indian
Pitaria circinata Born and its var. *alternata* Broderip West Indian and Pacific
Antigona multicostata Sowerby Pacific
Antigona rugosa Gmelin West Indian and Pacific
Macrocallista maculata Linné West Indian
Chione grus Holmes West Indian
Tellina crystallina Chem. West Indian and Pacific
Strigilla pisiformis Linné West Indian
Mactra exoleta Gray Pacific
Mactra alata Spengler West Indian
Labiosa lineata Say West Indian
Corbula Dietziana C. B. Adams West Indian
Tellidora cristata Recluz West Indian
Conus proteus Hwass West Indian
Conus floridanus Gabb var. *costaricensis* Olsson West Indian
Terebra benthalis Dall var. *bocasensis* Olsson West Indian

Turris albida Perry West Indian
Glyphostoma dentifera Gabb West Indian
Acteocina bullata Kiener var. *costaricana* Olsson West Indian
Acteocina recta d'Orb. West Indian
Volvula cylindrica Gabb West Indian
Ancistrosyrinx elegans Dall variety West Indian
Marginella avena Valen West Indian
Murex messorius Sowerby West Indian
Bursa crassa Dillwyn West Indian
Natica canrena Linne West Indian
Architectonica granulata Lamarck West Indian nnd Pacific
Astralium brevispinum Lamarck, variety *basalis* Olsson West Indian
Astralium caelatum Gmelin West Indian
Sistrum nodulosum C. B. Adams West Indian
Latirus infundibulum Gmelin West Indian
Northia northiæ variety *miocenica* Olsson Pacific
Crepidula plana Say West Indian
Xenophora conchyliophora Born West Indian
Oliva testicea Lamarck var. *costaricensis* Olsson

It is but natural to expect that the Miocene beds along the northern or Caribbean coast of Central America, should contain a fauna largely ancestral to that of the present Caribbean, but along with these strictly Caribbean types, we also find several species, identical or closely related to forms now restricted to the Pacific side. Their occurrence in Caribbean deposits points to a connection between the Atlantic and Pacific oceans during Miocend time and allows for a certain intermingling of their faunas. Geological observations indicate that there were at least two such straits crossing Central America during the Miocene, the main one across Costa Rica, and a second through the Darien of eastern Panama.

This Pacific element of the Gatun fauna comprises many of the most common and characteristic species. Certain of these species had a wide distribution in the West Indies during Mio-

cene time and have been noted by several writers. They comprise the following species from Panama and Costa Rica, listed together with the Pacific analogues:

Panama or Costa Rica	Pacific Analogue
Arca Patricia Sowerby	*Arca grandis* Sowerby
Arca (*Noetia*) *MacDonaldi* Dall	*Arca reversa* Sowerby
Ostrea megodon Hanley	
Mactra exoleta Gray	
Mactra estrellana Olsson	*Mactra* (*Harvella*) *elegans* Sowerby
Semele laevis Sowerby var. *costaricensis* Olsson	*Semele laevis* Sowerby
Macoma panamensis Dall variety *canalis* Olsson	*Macoma panamensis* Dall
Macoma gatunensis Toula	*Macoma elongata* Hanley
Tellina crystallina Chemnitz	also West Indian
Antigona multicostata Sowerby	
Antigona rugosa Gmelin	also West Indian
Pitaria circinata Born variety *alternata* Broderip	
Cyclinella subquadrata Hanley variety *quitana* Olfson	*Cyclinella subquadrata* Hanley
Cyclinella beteyensis Olsson	*Cyclinella Kroyeri* Philippi
Conus recognitus Guppy	*Conus pyriformis Reeve*
Turricula lavinoides Olsson	*Turricula lavina* Dall
Cancellaria islacolonis Maury	*Cancellaria tesselata* Sowerby
Cancellaria toroensis Olsson	*Concellaria tuberculosa* Sowerby
Cancellaria Plummeri Olsson	*Cancellaria bullata* Sowerby
Mitra Swainsoni Brod. variety *limonensis* Olsson	*Mitra Swainsoni* Broderip
Neverita nereidis Maury	*Neverita glauca* Humbolt
Northia northiae Gray variety *miocenica* Olsson	*Northia narthiae* Gray
Malea camura Guppy	*Malea ringens* Swainson
Oliva testacea Lam. variety *costaricensis* Olsson	*Oliva testacea* Lam

With the closing of the Miocene straits, this Pacific element gradually had to give way before the development of the West Indian fauna, but it is still to be seen in such species as, *Tellina crystallina* Chem. *Architectonica granulata* Lamarck, which have a distribution along both coasts. Moreover the Pliocene

and Pleistocene beds of Central America contain a well-marked Pacific element in such species as *Northia northiæ* Gray *Oliva testacea* Lamarck and *Pecten ventricosus* Sowerby.

CORRELATION

Miocene rocks are now known from a great many localities in the West Indies and the general Caribbean area of Central and South America. In these areas they comprise a very important series of sedimentary formations. Beds equivalent to the Gatun, appear to be the most widespread and generally are highly fossiliferous.

The following chart showing the equivalence of the Miocene horizons in the West Indies and elsewhere to those of Central America, does not differ materially from the more recent correlations proposed by Maury, Cooke or Vaughan, except in the addition of the Uscari to the Lower Miocene of Panama and Costa Rica. The Gatun formation is here recognized as being of Middle Miocene age with possibly some of its upper beds having Upper Miocene affinities. The Gatun, at its type locality in the Central Zone, is not more than 500 to 600 feet thick. In Costa Rica it is very much thicker, and its higher beds may range into the Upper Miocene. It is the exact equivalent of the Chesapeake Miocene of the eastern United States. In this correlation, I have been guided not only by the paleontologic evidence, but also by the field relations of the formations, studied over a wide rage of country in Costa Rica, and in Panama as far east as the Colombia frontier.

SANTO DOMINGO MIOCENE

In Santo Domingo and in Haiti, Miocene rocks are exposed in several areas, but attain their best development along the valley of the Rio Yaque del Norte in the northern part of the island. These beds are highly fossiliferous and because of the fine perservation of their fossils, have repeatedly attracted the attention of paleontologists.

The earlier writers dealing with the paleontology of the Dominican Miocene, believed that it represented but a single

stratigraphic unit, and Gabb insisted that no division was possible. Dr. Maury however, as a result of paleontologic studies from collections carefully made in the field, was able to divide the Dominican Miocene into two formations, which she called the Gurabo and the Cercado. To these Vaughan and his associates, in more recent stratigraphic work on the island, have added 4 other subdivisions. The present recognized subdivisions of the Dominican Miocene are:

MIOCENE	MIDDLE	Mao clay Mao Adentro limestone Gurabo formation (*Sconsia laevigata* zone)
	LOWER	Cercado formation (*Aphera islacolonis* zone) Baitoa formation and Bulla conglomerate

The relation of the Costa Rican and Panama Miocene to that of Santo Domingo is extremely close; there being about 90 species in common. Of this number about 21 are recent, about 26 species appear to be restricted to the Gurabo, some 27 species are common to both the Gurabo and Cercado formations, and only 11 species are confined to the Cercado. The list of of Costa Rican and Panama species in the Dominican Miocene, is as follows:

Nucula tenuisculpta Gabb	Cercado and Gurabo
**Arca occidentalis* Phil	Cercado and Gurabo
**Arca umbonata* Lamarck	Cercado
Arca Mauryæ Olsson	Gurabo
Arca Henekeni Maury	Cercado
Arca golfoyaquensis Maury	Cercado and Gurabo
Arca chiriquiensis Gabb	Gurabo
**Arca auriculata* Lamarck	Gurabo

*Recent

Glycymeris jamaicensis Dall Cercado
Limæa solida Dall Gurabo
**Ostrea megodon* Hanley Gurabo
Spondylus gumanomocon Brown and Pilsbry, Gurabo
**Anomia simplex* d'Orb Gurabo
Placunanomia lithobleta Dall Gurabo
Pteria inornata Gabb Cercado and Gurabo
**Cardium serratum* Linné Cercado and Gurabo
Cardium dominicensis Gabb
**Cardium medium* Linné Gurabo
Protocardia gurabica Maury Cercado
**Mactra alata* Spengler Cercado
Antigona tarquina Dall? Cercado
Antigona Blandiana Guppy Gurabo
**Pitaria circinata* Born Cercado
**Tellina crystallina* Chemnitz Cercado
Tellina cercadica Maury Cercado
**Strigilla pisiformis* Linné Cercado
Semele Claytoni Maury Cercado
Venericardia scabricostata Guppy Cercado and Gurabo
Echinochama yaquensis Maury Gurabo
Corbula vieta Guppy Cercado and Gurabo
Corbula viminea Guppy Cercado
**Acteocina recta* d'Orb Cercado
Acteocina triticum-tritonis Maury Cercado and Gurabo
**Volvula cylindrica* Gabb Cercado
Bullaria paupercula Sowerby Cercado and Gurabo
Ringicula dominicana Maury Cercado
Terebra spirifera Dall Cercado
Terebra bipartita Sowerby Gurabo
Terebra haitensis Dall Gurabo
Terebra Berlineræ Maury Gurabo
Conus haytensis Sowerby Cercado and Gurabo
" *Sewalli* Maury Gurabo

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*Recent

Conus stenostomus Sowerby Gurabo
Conus proteus Hwass Cercado and Gurabo
Conus recognitus Guppy Cercado and Gurabo
Conus multiliratus Bose Gurabo
Conus gracilissimus Guppy Cercado and Gurabo
Conus marginatus Sowerby Gurado
Conus consobrinus Sowerby Cercado and Gurabo
Conus domingensis Sowerby Gurabo
**Turris albida* Perry Cercado and Gurabo
Drillia venusta Sowerby Gurabo
Drillia consors Gurabo
Cythara heptagona Gabb Gurabo
**Glyphostoma dentifera* Gabb Gurabo
Cancellaria Mauryæ Olsson Cercado and Gurabo
Cancellaria Rowelli Dall
Cancellaria epistomifera Guppy Cercado and Gurabo
Cancellaria islacolonis Maury Cercado
Oliva brevispira Gabb Cercado and Gurabo
Oliva cylindrica Sowerby Cercado and Gurabo
Olivella muticoides Gabb Cercado and Gurabo
Mitra rudis Gabb Cercado and Gurabo
Mitra longa Gabb Cercado and Gurabo
**Latirus infundibulum* Gmelin Gurabo
Melongena consors Sowerby Cercado and Gurabo
Alectrion losquemadica Maury Gurabo
Metula cancellata Gabb Gurabo
Murex cornurectus Guppy Cercado and Gurabo
**Murex messorius* Sowerby Gurabo
Typhis alatus Sowerby Gurabo
Distortio simillima Sowerby Gurabo
**Bursa crassa* Dillwyn Gurabo
Cassis sulcifera Sowerby Cercado and Gurabo
Sconsia lævigata Sowerby Gurabo

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*Recent

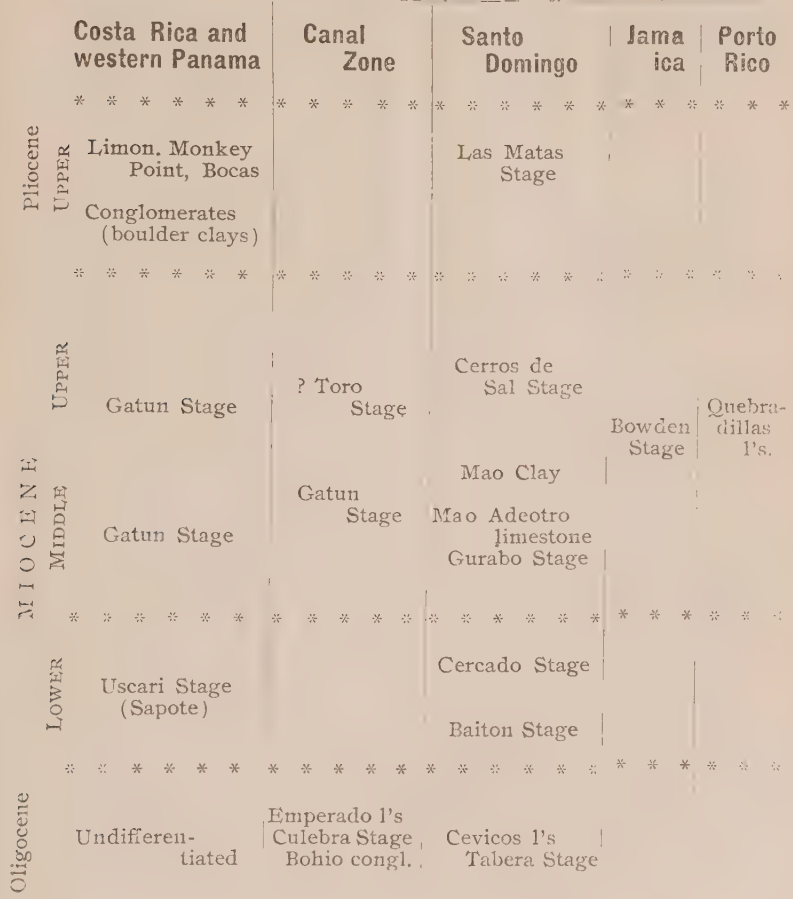
Dolium camura Guppy	Gurabo
Dolium elliptica Pilsbry and Johnson	Gurabo
Cypraea Henekeni Sowerby	Cercado and Gurabo
Cypraea dominicensis Gabb	Gurabo
Strombus pugiloides Guppy	Gurabo
Serpulorbis papulosa Guppy	Cercado and Gurabo
Petaloconchus sculpturatus H.C.Lea	Cercado and Gurabo
**Architectonica granulata* Lamarck	Cercado
**Xenophora conchyliophora* Born	Gurabo
**Natica canrena* Linné	Cercado and Gurabo
Natica Youngi Maury	Cercado and Gurabo
Polinices subclausa Sowerby	Cercado and Gurabo
Polinices Stanislas-Meunieri Maury	Gurabo
Neritina viridemaris Maury	Corcado and Gurabo
Neverita nereidis Maury	Cercado

Most of the above listed species belong to the Gatun formation. *Cancellaria (Aphera) islacolonis* Maury, *Neverita nereidis* Maury and *Corbula viminea* Guppy occur in the Upper Uscari and in the Lower Gatun or transitional beds of eastern Costa Rica. This leaves but the following 8 Cercado species in the Gatun fauna, or a proportion of about 3.25 to 1.

Arca Henekeni Maury	Winter Cay
Glycymeris jamaicensis Dall	Winter Cay
Protocardia gurabica Maury	Water Cay and Gatun
Antigona tarquinia Dall ?	Saury
Tellina cercadica Maury	Saury
Semele Claytoni Maury	Hotel Creek
Corbula viminea Guppy	Middle Creek
Ringicula dominicana Maury	Middle Creek, Red Cliff Creek and Estrella River

*Recent.

GENERAL CORRELATION CHART NO. I.



GENERAL CORRELATION CHART NO. II.

Colombia and Venezuela	Mexico	Eastern United States	
			Caloosahatchie
			Waccamaw
	Contemporaneous	Chesapeake Series Upper	Yorktown and Duplin Stage
	Txuetepec, State of Oaxaca		Murfreesboro Stage
Cartagena and Cumana	Santa Rosa and Barranca de Santa		
	Maria Tatetla, State of Vera Cruz	Chesapeake Series Lower	St. Mary's Stage
			Choptank Stage
			Calvert Stage
	Rio Coatzacoalcos, Isthmus of Tehuantepec	Alum Bluff Series and Stage	Shoal River marls Oak Grove marls Chipola marls
			Tampa Stage
			Vicksburgs Stage

The *Arca Henekeni*, *Glycymeris jamaicensis* and *Protocardia gurabica* occur with a typical Gatun fauna at Water Cay, western Panama, associated with *Sconsia*, and other Gurabo shells. With the exception of *Ringicula dominicana*, the other species are generally rare. The evidence is therfore strongly in favor of the equivalence of the Gatun beds with the Gurabo of Santo Domingo.

BOWDEN BEDS, JAMAICA

Next to Santo Domingo, the highly fossiliferous beds at Bowden, Jamaica, are the best known. From this locality, Dall has listed about 435 species, of which 12 per cent. appear to be identical with recent species.

Recent correlation by Cooke places the Bowden beds as equivalent to the Gurabo formation of Santo Domingo, and therefore to the Gatun formation; a correlation which is borne out by our own studies. About 38 Gatun species, not including recent forms, are here considered equivalent to Bowden shells. In general, the Costa Rican localities which show the closest agreement with Bowden, are the upper coralline horizons, so that the Bowden beds may be a little higher than the main Gurabo and they are so considered here. The following Bowden shells occur in the Costa Rican Gatun.

**Acteocina bullata* Kiener
**Acteocina recta* d'Orb
**Volvula cylindrica* Gabb
Bullaria paupercula Sowerby
Terebra bipartita Sowerby
Conus planiliratus Sowerby
Conus stenostomus Sowerby
Conus granozonatus Guppy
Conus recognitus Guppy
Conus interstinctus Guppy
Conus gracilissimus Guppy
**Turris albida* Perry
Petaloconchus sculpturatus Lea
Alaba turrita Guppy
**Crepidula plana* Say
**Nrtica* near *canrena* Linne
Glycymeris jamaicensis Dall
**Arca occidentalis* Philippi
**Arca auriculata* Lamarck
**Ostera megodon* Hanley
Limæa solida Dall
Placunanomia lithobleta Dall
Echinochama antiquata Dall

*Recent

Drillia consors Sowerby
Drillia venusta Sowerby
Cancellaria Barretti Guppy
Oliva cylindrica Sowerby
**Latirus infundibulum* Gmelin
Melongena consors Sowerby
Metula cancellata Gabb
Typhis alatus Sowerby
Distortrix simillima Sowerby
**Bursa crassa* Dillwyn
Cassis sulcifera Sowerby
Sconsia sublævigata Guppy
Strombus pugiloides Guppy
Venericardia scabricostata Guppy
Myrtæa limoniana Dall
Phacoides actinus Dall
**Lævicardium serratum* Linne
Cytherea Blandiana Guppy
Tellina lepidota Dall
**Strigilla pisiformis* Linne
Abra triangulata Dall
Corbula viminea Guppy
Gastrochæna rotunda Dall
Phalium moniliferum Guppy
Malea camura Guppy
Serpulorbis papulosa Guppy

MEXICAN MIOCENE

From Mexico, Bose† has described several small faunas from the Isthmus of Tehuantepec, and from the States of Oaxaca and Vera Cruz. These faunas, he considered as Upper Miocene and Pliocene.

The most interesting of these localities, in the present connection, are those at Tuxtepec in the State of Oaxaca, and Santa Rosa and the Barranca de Santa Maria Tatetla in the State of Vera Cruz. From these localities, we may note together with their Costa Rican and other affinities, the following species:

Pecten santarosanus Bose
Amusium Mortoni Ravenel
Lævicardium sublineatum Conrad
Anomia simplex d'Orb
Venus Ebergenvii Bose
Solarium Villarelloi Bose
Vermetus pulcher Bose
Strombus pugilis Linne
Sconsia sublævigata Guppy
Phos mexicanus Bose
Melongena Mengeana Dall
Pecten levicostatus Toula Gatun
Amusium luna Brown and Pilsbry Gatun Chesapeake Miocene
Gatun-Chesapeake to recent
Chione ulocyma Dall Upper Chesapeake
Architectonica granulata Lamarck Lower Miocene or recent
Serpulorbis sculpturatus H. C. Lea Gatun and Upper Chesapeake Miocene
Strombus pugiloidis Guppy Gatun
Bowden
Gatun of Water Cay
Solenosteira Vaughani Dall variety *medioamericana* Olsson, Gatun of Water Cay

* Recent.

† Boletin del Instituto Geologico de Mexico, No. 22, 1919, pp. 11 - 88

Fleurotoma alesidota Dall var.
magma Bose.....*Drillia consors* Sowerby, Gatun
Conus Agassizi Dall variety
multiliratus Bose.....*Conus multiliratus* Bose, Gatun
Conus Burckharti Bose..... Gatun

The above species are from Tuxtepec and Santa Rosa. To these we may add, from Barranca de Santa Maria Tatetla, the following forms:

Ostrea sculpturata Conrad.....*Ostrea costaricensis* Olsson, Gatun
Lucina quadrisulcata Linné.....*Divaricella quadrisulcata* d'Orb
Gatun, Upper Chesapeake Miocene to recent
Lævicardium serratum Linné.....Gatun, Upper Chesapeake to recent
Dosinia acetabulum Conrad.....Gatun - Chesapeake Miocene

The above list is but a partial one of the entire fauna from these localities. However, it shows the close relationship between these Mexican species and those of the Gatun and the Bowden, such as *Sconsia sublævigata*, *Phos mexicanus*, *Conus multiliratus* and others, with a few typical Chesapeake species such as *Chione ulocyma* Dall, *Dosinia acetabulum* Conrad and *Cardium sublineatum* Conrad. This illustrates the intermingling of the Gatun-Bowden-Gurabo fauna with that of the Chesapeake, and proves their equivalence in age.

THE EAST COAST MIOCENE

A fine development of Miocene rocks is found along the Atlantic coastal plain and they extend more or less continuously from New Jersey south into Florida. They are continued around the borders of the Gulf of Mexico into Texas, but in these regions, their marine phases are deeply covered by younger formations, and they are known only from deep wells. These Miocene beds are divisible into two series, which early were classified as (a) the older or sub-tropical Miocene and (b) the younger and cold-water Miocene. These terms are descriptive of their main faunal differences. The upper division consisting of sever-

al formations or stages is frequently known as the Chesapeake Miocene or Chesapeake series, and the lower consisting solely of the Alum Bluff formation, may be designated for sake of discussion, the Alum Bluff series. These Miocene formations or stages are the following:

MIOCENE	Upper		Yorktown, Duplin Stages Murfreesboro Stage
	* * * *	Chesapeake Series	* * * * * * * * *
	Middle		St. Mary's Stage Choptank Stage Calvert Stage
	* * * *	* * * * * *	* * * * * * * * *
			Alum Bluff Stage — Shoal River marl
	Lower	Alum Bluff Series	Oak Grove marl Chipola marl

This two-fold division is a very natural one. Each series represents a distinct trangression of the Miocene sea over parts of the Atlantic coastal plain, that of the Chesapeake being the more extensive. In Florida, where the Chesapeake Miocene is sometimes found resting upon the Alum Bluff beds, as at Alum and Jackson Bluffs, the contact is seen to be an erosional unconformity. At these localities, the Chesapeake Miocene is equivalent to the Murfreesboro stage or formation of Virginia and North Carolina, and hence the time interval represented by this break is equivalent to the Lower Chesapeake or the Marylandian Miocene. Dall,* who has paid special attention to the relations of the Alum Bluff and the Chesapeake series, both stratigraphically, and paleontologically, characterizes this break as "the most sudden, emphatic, distinct in the whole post-Cretaceous his-

* Trans, Wagner Free Inst., 1903, p. 1594

tory of our southeastern Tertiary, and indicates physical changes in the surrounding region, if not in Florida itself, sufficient to alter the course of ocean currents and wholly change the temperature of the waters of our southern coasts."

The fauna of the Lower Miocene or Alum Bluff series is of warm-water character and largely composed of Antillean types. In the Chesapeake series, the fauna is of cold or temperate-water character and it finds its relations with the present Atlantic fauna north of Cape Hatteras. These faunal differences must be take into account in any correlation between the Miocene of the United States with that of the West Indies and Central America.

In the Correlation Charts, I have placed the Gatun formation as equivalent to the Chesapeake series, the Uscari formation with the Alum Bluff. The evidence upon which this correlation is based, may be summarized as follows:

1. The two-fold division of the Costa Rican and Panama Miocene, by an unconformity at the base of the Gatun formation.

2. Wherever the Gatun beds have been found overlain by more recent formations, the age of these overlying beds is Pliocene or younger.

3. The high percentage of recent species in the Gatun fauna, which agrees with the average as shown for the Cheapeake Miocene.

4. The Gatun fauna, contains a few species which appear identical with strictly Chesapeake species, such as the following:

Dosonia acetabulum Conrad
Petaloconchus sculpturatus H. C. Lea
Chama congregata Conrad
Plicatula marginata Say ?

The *Dosinia acetabulum* Conrad is one of the most abundant and characteristic species of the Chesapeake Miocene and in its course through the Chesapeake formations, several varieties are developed, of great use in correlation. The typical *acetabulum* is however confined to the Upper Chesapeake formations and it was figured by Conrad in his Medial Tertiary, from a fine large example from Smithfield, Virginia. It is characterized by its large size, broad outlines and even, concentric banding. This Upper Chesapeake or typical *acetabulum* corresponds very closely in size, form and sculpture to the Costa Rican examples. It is very common at certain localities in Costa Rica, especially in the lower part of the Gatun formation. Bose records it from Mexico. The *Petaloconchus sculpturatus* is a widely distributed species in the West Indies and Caribbean Miocene, from which it is more generally recorded as *P. dominigensis*, a name given to the Santo Domingian shell by Sowerby. Close comparative study of a large collection of typical *sculpturatus* from Virginia and North Carolina, failed to show any real difference, either in details or sculpture or in nature of coiling. The *Petaloconchus sculpturatus* occurs in the Bowden beds of Jamaica; the Gurabo formation of Santo Domingo; the Quebradillas limestone of Porto Rico; the Springvale beds of Trinidad; and the Gatun of Panama and Costa Rica. It is also known from Cumana, Venezuela: Cartagena, Colombia; and Santa Rosa, Mexico. In the Chesapeake Miocene, it is restricted to the Murfreesboro, Yorktown and Duplin formations, that is, to the Upper Chesapeake. It does not occur in the overlying Pliocene so far as is known.

5. Possibly more significant because of their greater number are the following species, which appear for the first time in the Atlantic coast Miocene in the Chesapeake formations. They also continue into the Pliocene and generally into the recent fauna.

Anomia simplex d'Orb	St. Mary's to recent
Cardium spinosum var. *Turtoni* Dall	Murfreesboro to recent
Cardium serratum Linné	Murfreesboro to recent
Cardium medium Linné	St. Mary's to recent
Labiosa lineata Say	Duplin to recent
Tellina umbra Dall	Duplin to recent
Chione grus Holmes	Duplin to recent
Phacoides radians Conrad	Duplin to recent
Phacoides trisulcatus Conrad	Chesapeake to recent
Divaricella quadrisulcata d'Orb	Murfreesboro to recent
Oliva sayana var. *immortua* Pilsbry and Brown	typical shell, upper Chesapeake to recent
Fasciolaria tulipa Linné	Pliocene

THE COSTA RICAN GEOSYNCLINE

The wide distribution of Miocene beds around the borders of the Gulf of Mexico and Caribbean sea, indicates a condition of general deposition during Miocene time. Costa Rica was largely under water, at least during the Lower Miocene, and was the locus of a strait or geosyncline that then connected the Atlantic and Pacific Oceans; while Panama, parts of Nicaragua, and other central American areas were mainly above sea level. This condition is shown in the general igneous character of the backbone of Panama, while in Costa Rica, sedimentary rocks of Miocene age occur even in the high interior and at elevations of several thousands of feet. This geosyncline covered the greater part of Costa Rica, a portion of western Panama, and western Nicaragua. It should be noted that this area, at the present time, is the locus of a large number of active volcanoes.

Certain changes of importance took place at the close of Uscari time, resulting in a brief withdrawal of the Miocene sea. The effects of these changes were widespread. These great land movements, which probably reached a culmination in the Plio-

cene, had far reaching consequences and to them we must ascribe even the sudden and marked change between the fauna of the Alum Bluff and Chesapeake series of the eastern United States. It probably resulted in a partial closing of the Atlantic-Pacific straits and a disarrangement of the direction of oceanic currents. The strongly clastic character of the Gatun formation as compared with the more shaly Uscari, is also a result of the elevation of the land.

The Pliocene was a period of high elevation and, in Costa Rica, of intense volcanic activity. The coarse conglomerates, or the so-called boulder clays, which have perplexed most geologists who have visited Costa Rica, were formed from the erosion of these Pliocene lava flows and deposited as flood-plain material. In a few localities where these conglomerates reached the sea, they contain intercalated shale beds carrying marine fossils of late Pliocene age.

MOLLUSCA

CLASS GASTROPODA

ORDER OPISTHOBRANCHIATA

SUBORDER TECTIBRANCHIATA

Genus **ACTAEON,** Montfort

Actæon costaricensis, n. sp.

Shell moderately large, ovate-cylindric; body-whorl large and more than ¾ of the total length of the shell; spire pointed, conic; whorls about 6, convex and with deep sutures; spiral sculpture of fine, nearly regular, smooth threads separated by deep and somewhat wider interspaces; there are about 9 spiral threads on the spire-whorls and about 34 on the last whorl; the interspaces are crossed by fine, elevated, distant threads; aperture linear-lanceolate, rounded below; columella with a single large fold.

Height 19.5 mm, diameter 10 mm, aperture 14. 5 mm.

This is an unusually large and cylindrical species with a relatively high spire. Suggestion of the original coloration is indicated by a white band which encircles the middle of the last whorl commencing at the upper end of the aperture,— the general ground-color of the surface being a faint purple or reddish brown. The interspaces between the spirals are crossed by fine, elevated threads, but they appear merely punctate on the early whorls.

Gatun Stage: Hill No. 3, Banana River.
Middle Creek.

Genus **ACTEOCINA,** Gray

Acteocina bullata Kiener, var. **costaricana,** n. var. Plate 15 figures 20, 21

cf. *Tornatina bullata* Kiener, Icon. Coq. Viv., p. 5, pl. 1, fig. 4.

Shell rather large, moderately solid; outlines subcylindrical but a little wider about the anterior half of the shell; the spire is short, composed of 4 or more whorls, and a small nucleus of the usual type, as in *canaliculata;* sutures channelled; the surface appears smooth, until slightly magnified when it is seen to be covered with very fine spiral lines; columella carries a single strong fold.

Height 10, diameter 3, aperture 9 mm.

The Costa Rican fossils are related to the recent *A. bullata* Kiener, of the West Indies but differ in their shorter spire and are somewhat more expanded about their anterior half. It is the largest species in the Costa Rican Miocene, often reaching a length of 10 mm. Its surface is covered with fine, spiral lines and the columella carries a single, strong plication.

Gatun Stage: Middle Creek.
Coll. 4, East Grape Point Creek.

Acteocina recta d'Orbigny

Bulla recta d'Orbigny, 1845, De las Sagra, Hist. Pol. y Nat. Isla de Cuba, vol. 5, p. 67, no. 55; Atlas 8, pl. 4, *bis*, figs. 16-20.
Tornatina recta Gabb, Trans. Phil. Soc., vol. 15, p. 246.
Tornatina coix-lacryma Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 22, p. 518. Probably not of Guppy, 1867.
Acteocina recta Maury, 1917, Bull. Amer. Pal., vol. 5, p. 178, pl. 3, fig. 3.

A small species, typically with a short exserted spire and a broadly cylindrical form. The Costa Rican examples are all less than 3 mm in height. There is considerable variation in the height of the spire, which may be sunken in some cases as illustrated by the larger *coix-lacryma* Guppy from the Miocene of Venezuela and Martinique, to others with high spires and strongly descending whorls as in the recent *canaliculata* Say. However they all appear to belong to the same species. From the young of *bullata* var. *costaricana*, they are at once distinguished by their smooth, plain surface.

Gatun Stage: Coll. 7, Estrella River.
Coll. 5, Red Cliff Creek.

Subgenus **CYLICHNELLA**, Gabb

Acteocina triticum-tritonis Maury

Cylichnella bidentata Gabb, 1873, (in part) Trans. Amer. Phil. Soc., vol. 15, p. 273. Not of d'Orbigny, 1845.

Cylichna bidentata Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 518.

Acteocina (*Cylichnella*) *triticum-tritonis* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 178, pl. 3, fig. 4.

This shell was separated by Dr. Maury from the recent *bidentata* d'Orbigny, with which Gabb, Guppy and others had identified it. In *triticum-tritonis* the anterior of its plications is very small, the posterior one large, which is the reverse of the conditions as seen in the living *bidentata*. The base of the shell is finely grooved with incised, spiral lines. The specimens from Costa Rica agree very closely with typical specimens from the Miocene of Santo Domingo.

Gatun Stage: Middle Creek.

Genus **VOLVULA**, A. Adams

Volvula cylindrica Gabb

Volvula cylindrica Gabb, 1873, Trans. Amer. Phil. Soc.. vol. 15, p. 246.

Volvula cylindrica Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 518.

cf. *Bulla* (*Volvula*) cf. *oxytata* Toula, 1908, Jahrb. der K-K. Geol. Reichsanstalt, Wien, vol. 58. p. 709, pl. 28, fig. 4.

Volvula cylindrica Maury, 1917, Bull. Amer. Pal., vol. 5, p. 180, pl. 3, fig. 5.

This, is a small species of no unusual characters. It is narrowly cylindrical in form, shortly produced and pointed at its posterior extremity. It was described by Gabb from the Miocene of Santo Domingo, but Dall united with it, the *oxytata* Bush, in which case, it is also found in the recent fauna. Gabb records *acuta* d'Orb. from the Pliocene of the Limon Peninsula.

Uscari Stage: Middle Creek.

Genus **BULLARIA**, Rafinesque

Bullaria paupercula Sowerby Plate 4, figure 14

Bulla paupercula Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 52.

Bulla paupercula Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 246.

Bulla paupercula Guppy, 1874, Geol. Mag. London, p. 437.

Bulla paupercula Guppy, 1876, Journ. Geol. Soc. London, vol. 32, p. 518.

Bulla paupercula Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p. 18.

Bulla striata Dall, 1903, Trans. Wagner Free Inst., Sci., vol. 3, pt. 6, p. 1583.

Bullaria paupercula Maury, 1917, Bull. Amer. Pal., vol. 5, p. 182, pl. 3, fig. 8.

Bullaria paupercula Maury, 1920, N. Y. Academy of Science, Tertiary Mollusca of Porto Rico., vol. 3, pt. 1, p. 75.

This species is rare in Costa Rica, and all our specimens are from the Lower Gatun rocks of Middle Creek. It is possibly identical with the recent *Bullaria amygdala* Dillwyn, abundant on the beaches along the northern coast of Panama and Costa Rica.

Gatun Stage: Middle Creek.

Genus **RINGICULA**, Deshayes

Ringicula dominicana Maury

Ringicula semistriata ? Gabb, 1875, Trans. Amer. Phil. Soc., vol. 15, p. 225. Not *R. semistriata* d'Orbigny.

Ringicula dominicana Maury, 1917, Bull. Amer. Pal., vol. 5, p. 185, pl. 3, fig. 11.

This is the most abundant of the Opisthobranch mollusks in the Miocene beds of Costa Rica. The whorls are in general more strongly sculptured with incised lines than typical *dominicana* from the Miocene of Santo Domingo, and the spiral lines extent over the greater part of the shell, except for a wide, smooth band about the suture.

The *R. hypographa* Brown and Pilsbry, from Gatun is a larger shell with a heavier outer lip and more crowded spiral lines about the base. The Costa Rican shells measure about 1.5 mm or less in height.

Gatun Stage: Middle Creek. Coll. 5, Red Cliff Creek. Coll. 7, Estrella River.

ORDER CTENOBRANCHIATA

(A) SUPER-FAMILY TOXOGLOSSA

GENUS **TEREBRA** ADANSON

Terebra subsulcifera Brown and Pilsbry

Terebra subsulcifera Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 339, pl. 22, fig. 7.

Terebra (*Myurella*) *subsulcifera* Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 14, pl. 1, fig. 25.

The single, fragmentary specimen comes from the Gatun beds of Mt. Hope in the Canal Zone. From *bipartita*, which it resembles in its sculpture, this species and *haitensis* Dall, differ in having only a single columellar fold.

Gatun Stage: Mt. Hope, Canal Zone.

Terebra cf. **haitensis** Dall Plate 1, figure 3

Terebra haitensis Dall, 1895, Proc. U. S. Nat. Mus., vol. 18, p. 35.

Terebra haitensis Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1632, pl. 59, fig. 30.

Terebra haitensis Maury, 1917, Bull. Amer. Pal., vol. 5, p. 194. pl. 4, fig. 3.

The collection contains a single, imperfect shell from Sousci Creek, which should probably be referred to this species. From the *subsulcifera*, it differs in its more numerous and oblique ribs, and wider, less pronounced spiral bands. Like *subsulcifera*, the columella carries a single, sharp plication. Our specimen consisting of only 5 whorls measures 37 by 13 mm.

Gatun Stage: Sousci Creek, a branch of Hone Creek, C. R.

Terebra bipartita Sowerby Plate 1, figure 1, 2.

Terebra bipartita Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 5, p. 47.

Terebra bipartita Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 225.

Terebra (*Acus*) *bipartita* Dall, 1895, Proc. U. S. Nat. Mus., vol. 18, p. 38.

Terebra bipartita Maury, 1917, Bull. Amer. Pal., vol. 5, p. 187, pl. 3 fig. 14.

This species, possessing much the same type of sculpture as *sulcifera*, *subsulcifera*, *haitensis* etc., is recognized by having two, instead of one columellar plication. Full-grown specimens have a bipartite sculpture while in *sulcifera* and the others it is tripartite.

The Costa Rican collection contains three specimens from Saury creek, near Cahuita, the largest of 10 incomplete whorls mearures 77 by 19 mm.

Gatun Stage: Zone E. Saury Creek

Terebra gatunensis Toula Plate 1, figures 4-6

Terebra gatunensis Toula, 1909, Jahrb. der K-K Geol. Reichsanstalt, vol. 58, p. 705, pl. 25, fig. 14.

Terebra gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phil., vol. 63, p. 339, pl. 22, fig. 2.

Terebra wolfgangi Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phil., vol. 63, p. 340, pl. 22, figs. 1, 3-6, but not of Toula, 1908.

Terebra (*Myurella*) *gatunensis* Cossman, 1913, Jour. de Conchyliologie, vol. 61, p. 13, pl. 1, figs. 26-29.

In the Canal Zone, the Gatun beds contain two common species of *Terebra*, which were described by Toula as *gatunensis* and *wolfgangi*. These species have been more or less confused by Brown and Pilsbry, so that their figures and description of *wolfgangi*, really represent *gatunensis*. Their figure 2 is a large and less common variety of *gatunensis*. Toula's figure, although of a young imperfect shell, is clear and shows the main

characters of the species, the spirally striated, faint sutural sulcus and fine spiral sculpturing of the whorls. He however in his notes, allies this species with the recent *T. dislocata* of Say, which is misleading. Toula's figure can be duplicated by scores of specimens in our collection.

Terebra gatunensis is characterized by its large size, (length 50 mm or more), its faint sutural sulcus which may be smooth or with 2 or 3 faint spirals, showing best on young shells. The spiral cords of the main body of the whorl are variable in number, spacing and strength, as well as the longitudinal ribs. A large coarse variety, with persistent sulcus, and heavier sculpture occurs rarely and is shown by Brown and Pilsbry as their figure 2. The pillar is nearly smooth, carrying a very broad fold above, and a small one below.

Gatun Stage: Gatun and Mt. Hope, C. Z.

Terebra wolfgangi Toula Plate 1, figure 11, 12

Terebra wolfgangi Toula 1909, Jahrb. der K-K Geol. Reichsandstalt, vol. 58, p. 705, pl. 28, fig. 7.

Not *Terebra wolfgangi* Brown and Pils. which is *T. gatunensis* Toula.

Although *T. gatunensis* and *wolfgangi* have not been collected by us except in the Canal Zone, where they are abundant, they are included here for the sake of completeness. It is also not unlikely that future collecting may still reveal their presence in the synchronous beds in Costa Rica and adjacent parts of Panama.

T. wolfgangi differs from the common *T. gatunensis* by its long, tapering form, deep, persistent sulcus and a sutural band generally free from spirals. It is also a much smaller species, the largest specimen in our collection measuring about 38 mm in length.

Gatun Stage; Mt. Hope, C. Z.

Terebra gausapata Brown and Pilsbry Plate 1, figures 8, 10

Terebra gausapata Brown and Pilsbry, April 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 340, pl. 22, figs. 8, 9.

Terebra acuaria Toula, Dec. 1911, Jahnb. der K-K Geol. Reichanstalt, vol. 61, p. 19, pl. 2, fig. 19.

Terebra (*Myurella*) *acuaria* Cossm., 1913, Journ. de Conchyliologie, vol. 61, p. 12, pl. 1, figs. 19-24.

The *T. gausapata*, was described by Brown and Pilsbry, from young specimens, measuring only 19 mm in length. Later in the same year appeared Toula's *T. acuaria*, also based on young shells.

The important characters of this species, are its nearly straight ribs, deep sulcus, a sutural band with faint spirals and even sculpture. Figures 23 and 24 of Cossmann I believe represents *wolfgangi*. *T. wolfgangi* as will be noted from the accompanying figures is a much more slender species and usually with a smooth sutural band. The pillar carries two broad folds, which are better developed than in *wolfgangi* or *gatunensis*.

Length 33, breadth 8.5 mm.

Gatun Stage: Mt. Hope, C. Z.
Water Cay.

Terebra spirifera Dall Plate 1, figure 13

Terebra dislocata Gabb, 1873, Trans. Amer. Phil. Sci., vol. 15, p. 225, Not of Say.

Terebra (*Acus*) *bipartita* Sowerby, variety *spirifera* Dall, 1895, Proc. U. S. Nat. Mus., vol. 18, p. 38.

Terebra (*Oxymeris*) *bipartita* Sowerby, variety *spirifera* Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1632, pl. 59, fig. 13.

Terebra spirifera Maury, 1917, Bull, Amer. Pal., vol. 5, p. 188, pl. 3 figs. 15, 16.

In *T. Gatunensis* and *wolfgangi* the pillar is nearly smooth

or with two board, sub-obsolete folds. In *spirifera*, the two folds are strong and recall those seen in the recent *T. dislocata*. The sutural band is strongly sculptured by the end of the ribs which are entirely dislocated by the deep sulcus. Typical specimens have three or four, even spirals, which are stronger than the longitudinal ribs. Variation occurs in the number, and regularity or these spirals,

Length 43, breadth 9 mm.

Gatun Stage: Banana River, Hill No. 1.
Water Cay.

Terebra spirifera Dall, variety **midiensis**, n. var. Plate 1 figure 7

This variety, represented only by a single specimen from Middle Creek, C. R., differs from typical *spirifera*, in having only three spirals, which are broad and strap-like in form.

Gatun Stage: Middle Creek. C. R.

Terebra Berlinerae Maury Plate 1, figures 17, 18

Terebra Berlineræ Maury, 1917, Bull. Amer. Pal., vol. 5, p. 198, pl. 4, figs. 7, 8.

This beautiful species was described by Dr. Maury, from the Cercado (Miocene) formation of Santo Domingo. The whorls are slightly convex, and its sculpture is closer, finer and more delicate than is seen in any of the associated Costa Rican Terebras. Our specimens, all imperfect, were collected from the hard Gatun sandstones of Boucary Creek. The most complete specimen measures 21 by 6.5 mm.

Gatun Stage: Boucary Creek.

Terebra estrellana, n. sp. Plate 1, figures 9, 16

Shell small; nucleus of three smooth tapering whorls; post-nuclear whorls about 9, sculptured with a faint sutural sulcus, which is lacking or nearly so from the early whorls; axial sculpture of about eleven, straight or slightly oblique ribs which pass from suture to suture; but are nearly lacking from the base; spirals lacking or very faint on the spire-whorls, so that they appear smooth and solid; the base of the last whorl is strongly contracted and shows four or five, very faint spirals; pillar straight and smooth; beak twisted.

Length 7.5, diameter 2.5 mm.

This is a small species of rather solid appearance, strong ribs, but otherwise nearly smooth whorls. The spirals are very faint and are seen best only when viewed at right angles to the source of light. Our specimen came from the Estrella River.

Gatun Stage: Zone 7, Estrella River, C. R.

Terebra costaricensis, n. sp. Plate 1, figure 19

Shell small and slender, with about three, long, tapering smooth, nuclear whorls; post-nuclear whorls eleven; sutural band rather large and prominent, strongly tuberculated; the spire-whorls are slightly concave and have at their base or just above the suture, a revolving series of tubercles, which are the enlarged bases of the longitudinal ribs; longitudinal ribs on the last whorl number about twelve, are nearly straight and large and strong on each side of the suture, low and weak in the middle of the whorls; the surface of the whorls are otherwise smooth or in some shells feebly spiralled; base slightly rounded with eight or more spirals which become finer as they approach the canal; the longitudinal ribs are continued across these spirals.

Length 13, diameter 3 mm.

The above description is based mainly on two specimens

from Hill No. 3, of the Banana River. Our collection contains several smaller shells from Zone 7, of the Estrella River in which the base is somewhat more heavily sculptured and with very fine spirals over the main surface of the whorls.

Terebra benthalis Dall var. **bocasensis,** n. var. Plate 1, figures 25, 26

Cf. *Terebra* (*Acus*) *benthalis* Dall, 1889, Bull. Mus. Comp. Zool., vol. 18, p. 65, pl. 29, fig. 6.

This species, fairly abundant in the shale beds, just north of the city of Bocas del Toro, Panama, agrees closely with Dall's figure in the Blake Report, except that the revolving series of tubercles in the fossil shells seem to be lower and broader. The whole surface on slight magnification is seen to be finely spirally striated.

Terebra benthalis was described by Dall from specimens dredged from 100 to 400 fathoms of water off the Morro Light, Havana, Cuba. The species belongs to the section *Fusoterebra* Sacco.

Length 27, diameter 6.5 mm.

Gatun Stage: Bocas del Toro, Panama.

Terebra pumbriensis, n, sp. Plate 1, figure 27

Shell of medium size, composed of 9 whorls (type with a small portion of the apex lost); the early post-nuclear whorls (the 1st 3 or 4) with two revolving rows of tubercles, formed by the intersection of fine, oblique riblets and two spiral bands; on the 4th whorl of our specimen, a median spiral makes its appearance and rapidly increases in strength so that the later whorls have three rows of tubercles, the upper or most posterior one being somewhat the strongest; the longitudinal ribs are narrow and oblique, and on the last whorl number about 20; the space between the ribs have three or four fine, incised growth-lines; periphery of the base has an additional tuberculated spiral,

below which is a band composed of four smooth, close spirals; between these spirals and the keel is a deep, concave zone; pillar nearly straight and smooth, with a single sharp keel on the back.

Length 20, diameter 4.75 mm.

Of this interesting and distinctive species, we have only a single, imperfect specimen from the Gatun beds of Pumbri Creek. The three rows of tubercles are evenly spaced and there is no sutural band.

Gatun Stage: Pumbri Creek, C. R.

Genus **CONUS** Linné

Conus molis Brown and Pilsbry Plate 2, figures 1, 2

Conus molis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 343, pl. 23, fig. 1.
Conus molis Maury, 1917, Bull. Amer. Pal., vol. 5, p. 200.

This is the common Cone in the Gatun beds of Panama and Costa Rica and large specimens may reach a length of nearly 150 mm. The upper surface of the whorls carry 5 or more fine spirals and perfect examples of young shells have a few of the early post-nuclear whorls finely coronated. Described by Brown and Pilsbry from the Canal Zone, the species has also been collected by us at several stations along the Panama coast between Colon and Bocas, at Water Cay, and along the Banana River in Costa Rica. A large specimen from Water Cay measures: length 144 mm, width 81 mm.

Gatun Stage: Gatun, Water Cay, Banana River, etc.

Conus stenostomus Sowerby Plate 3, figure 2

Conus stenostoma Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 5 p. 44.
Conus stenostoma Guppy, 1866, *Id.*, vol. 22, p. 287, pl. 16, fig. 2.
Conus stenostoma Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 230.

Conus catenatus Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 527, in part b

Conus stenostomus Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1583.

Conus stenostomus Maury, 1917, Bull. Amer. Pal., vol. 5. p. 203, pl. 6, fig. 4.

A species characterized by its sharp angulated shoulder, concave upper surface of its whorls and attenuated anterior canal. Well-preserved examples showing a highly polished surface and traces of yellow blotches of color markings were collected quite abundantly in the coralline of Port Limon. The species also occurs in Jamaica and Santo Domingo.

Gatun Stage: Port Limon.

Conus concavitectum Brown and Pilsbry

Conus concavitectum Brown and Pilsbry, 1911. Proc. Acad. Nat. Sci. Phila., vol. 63, p. 341, pl. 23, figs. 5, 6.

Conus (*Lichoconus*) *concavitectum* Cossmann, 1813, Jour. de Conchyliologie, vol. 61, p. 43, pl. 4, figs. 3, 4.

In adult shells, the spire whorls become concave. The species is also recognized by its sharp shoulder and low spire. It may be confused with varieties of *proteus* but the sharp shoulder angle and spiralled spire whorls will separate it. Our specimens come from Water Cay, and measure 48 by 27 mm.

Gatun Stage: Canal Zone and Water Cay.

Conus proteus Hwass Plate 2, figures 3, 4

Conus proteus Hwass, 1789, Enc. Meth. vers, 1 pt. 2, p. 682.

Conus leoninus Hwass 1789, Enc. Meth. vers, 1 pt. 2, p. 683.

Conus proteus? Gabb, 1873, Trans, Amer. Phil. Soc., vol. 15, p. 232.

? Conus Berghausii ? Gabb, *Idem*, p. 232. Not of Hoernes, Foss. Wien. Beck. pl. 1, fig. 3.

Conus leoninus Gabb, 1881, Jour. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 359.

Conus proteus Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p. 26.

Conus proteus Maury, 1917, Bull. Amer. Pal., vol. 5, p. 206, pl. 6, fig. 11.

This is a common species in the Miocene and Pliocene beds of Costa Rica and Panama. It is generally possible to distinguish two forms, a smaller one which agrees with typical examples of *proteus* in form and coloration (which is frequently preserved,) and a larger and heavier type, like the so-called *leoninus*. This second variety may show several dark spiral bands in addition to the square yellow blotches. Such markings we have not observed on recent examples of *leoninus*.

Gatun Stage: Banana River, Port Limon, Water Cay. Pliocene: Monkey Point; Bocas.

Conus Veatchi, n. sp. Plate 2, figures 5, 8

Shell rather large, heavy and broad, with a low, nearly flat spire, but pointed, slightly projecting apex; spire-whorls about 10 in number, with a slightly raised border near the suture and marked with fine spirals which on the last whorl number 10 or 11; shoulder of the last whorl rounded or beveled; last whorl, large and broad, nearly smooth above, except for the very faint spirals, but with numerous, fine, irregular spirals on the canal; pillar straight; aperture straight and narrow, slightly wider below.

Length 43, breadth 28 mm.

The present collection contains two specimens, the larger of which from Water Cay, serves as the *holotype*. The species is very unlike any of the associated Gatun species in its low, nearly flat spire. The *Conus demiurgus* Dall, of the Chipola Miocene of Florida, is a related species.

It is named for Dr. A. C. Veatch, Director of the Exploration Work of the Sinclair Consolidated Oil Corporation, for his

interest and co-operation in obtaining the extensive collections which form the basis of the present work.

Gatun Stage: Water Cay, Panama.
Gatun, C. Z.

Conus floridanus, var. **costaricensis,** n. var. Plate 3, figures 3, 9

Shell conic, with a moderately high spire of about eleven whorls; profile of the spire flat or slightly concave to the long projecting apex seen in well-preserved specimens; shoulder angle rather sharp with the whorls slightly concave above between the sutures; spire-whorls generally show 3 or more faint, raised spirals and strongly arcuated growth lines; the last whorl below the shoulder angle is usually nearly smooth above (sometimes with faint spirals) but with heavy regular spiral groovings to the number of about fifteen on the canal; the canal is long, rapidly attenuated and usually somewhat flexed below.

Height 44, breadth 21 mm.

Type from the Gatun beds of the Banana River.

This fossil, quite common in Costa Rica, should probably be classed as a variety of the recent *Conus floridanus* Gabb, differing only in always being somewhat more slender. They also agree closely with Dall's figure of *Conus chipolanus* Dall from the Chipola Miocene of Florida.

Care should be taken in distinguishing this from *C. imitator* of the Canal Zone. In that species, the full-grown shell is larger, with nearly straight sides and finer irregular spirals on the canal.

Gatun Stage: Banana River; East Grape Point Creek.

Conus imitator Brown and Pilsbry Plate 2, figure 6

Conus imitator Brown and Pilsbry, April, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 342, pl. 23, fig. 4.

Conus Dalli Toula, Dec., 1911, Jahrb. der K-K Geol. Reichsanstalt, Wien, vol. 61, p. 508, pl. 31, figs. 23 a-d.

Conus (*Lithoconus*) *Dalli* Cossmann, 1913, Jour. de Conchyliologie, vol. 61. p. 41, pl. 3, figs. 30, 31, pl. 4, figs. 7, 8.

? *Conus Dall* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 212, pl. 7, fig. 15.

The *Conus Dalli* Toula is doubtless the young of *imitator* described earlier in the same year by Brown and Pilsbry. Figure 6 is of a specimen from Mt. Hope which measures 51 by 25 mm. From Costa Rica, the collection contains a series of perplexing Cones, which probably should be referred to this species. From *costaricensis* they differ in their nearly straight sides, more irregular spiral groovings on the anterior canal, and they usually show faint spirals over most of the body-whorl, which I have not observed on *costaricensis*. A large shell from Zone C of Comadre Creek near Cahuita, measures 65 by 29 mm.

Gatun Stage: Mt. Hope and Gatun C. Z.
Water Cay, Panama.
Banana River, East Grape Point Creek, Comadre, Middle Creek, C. R.

Conus recognitus Guppy Plate 2, figure 9

Conus solidus Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 45, Not *C. solidus* Sowerby, 1841.

Conus solidus Guppy. 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 287. pl. 16, fig. 1.

Conus recognitus Guppy, 1867, Proc. Sci. Assoc. Trinided, p. 171, Harris Reprint, Bull. Amer. Pal., vol. 8, p. 198.

Conus pyriformis Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 229, Not of Reeve, 1843.

Conus recognitus Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 527.

Conus recognitus Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1583.

Conus recognitus Maury, 1917, Bull. Amer. Pal., vol. 5, p. 209, pl. 7, fig. 9.

This species is easily recognized by its well-rounded shoulder and appressed sutures. It is closely related to the recent *C.*

pyriformis Reeve of the west coast of Central America but the fossil shells have generally a lower and flatter spire. It is also known from the Miocene of Santo Domingo, Jamaica and Trinidad.

Gatun Stage: Banana River, Hill No. 3.

Conus limonensis, n. sp. Plate 3, figures 7, 8

Shell rather large, but delicate and rather slender; spire low, concave to the slightly projecting apex; spire whorls 10 or more, nearly flat between the sutures or slightly concave due to a slightly raised border; spire-whorls with 3 or 4 low spirals which become faint on the later whorls so that they are nearly smooth; sutures deep; shoulders of the last whorl angled or somewhat raised; body-whorl long and slender, polished and smooth, except for a few faint spirals near the tip of the canal; anterior canal long and straight, evenly tapering.

Length 41, breadth 24 mm.

This species is based on 2 specimens from the coral limestones of Port Limon, where it is associated with *Conus stenostomus* and *planiliratus*. From *stenostomus*, its straight canal, low spire and nearly smooth, polished surface is most noticeable.

Gatun Stage: Port Limon, C. R.

Conus musaensis, n. sp. Plate 1, figures 22, 24

Shell small and solid; spire short, conic, composed of about 2 pellucid, globular and projecting whorls and 6 post-nuclear whorls; the spire-whorls are flat or slightly concave and project slightly over the anterior sutures; body-whorl with the upper half smooth, but with 12 deep grooves on the anterior canal which produce wide, spiral bands: these grooves are delicately incised by raised longitudinal lines; color markings are sometimes preserved, which appear as 8 narrow, gray bands on the upper half of the whorl.

Length 19, breadth 9 mm.

This small species, the Gatun analogue of the recent West

Indian *Conus Agassizi* Dall, is abundant along the Banana River and elsewhere in Costa Rica.

Gatun Stage: Banana River, Zone 6 Red Cliff Creek, C. R.

Conus cf. interstinctus Guppy Plate 3, figure 12

Conus interstinctus Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 288, pl. 16, fig. 3.

A single specimen from Hill 1, of the Banana River, agrees closely with Guppy's figure of this Jamaican species. The shell measures 39 by 20 mm. The spire is moderate in height, with a slightly concave profile. The spire-whorls are smooth between the sutures but also show a slight coronation. The last whorl carries about 15 narrow, widely spaced, spiral cords which anteriorly are slightly beaded.

Dr. Maury unites *interstinctus*, with Sowerby's *catenatus*, but that species is based on a very young and scarcely distinguishable specimen. We therefore prefer to compare the Costa Rican shell with Guppy's larger and well-figured *interstinctus*.

Gatun Stage: Banana River, Hill No. 1.

Conus cf. Sewalli Maury

Conus Sewalli Maury, 1917, Bull. Amer. Pal., vol. 5, . 201, pl. 5, fig. 3, pl. 6, fig 3.

The collection contains 2 young shells which may belong to this Dominican species. They differ from the preceding *interstinctus* in being shorter and broader, and the spire-whorls in place of being smooth are marked with 5 or 6 strong spirals. The last whorl is sculptured with 15 or more widely spaced beaded spirals. The dimensions of the largest shell are: Length or height 30, breadth 19 mm:

Gatun Stage: Banana River.

Conus toroensis n. sp. Plate 2, figure 7

Shell of medium size, with a conic spire a little more than ½ the length of the aperture; the whorls of the spire numbering

12 plus are flat or slightly concave and bordered below by a low carina projectly slightly above the suture; this carina on all except the last whorl bears low nodes, about 20 to the later whorls; the spire-whorls are otherwise smooth except for the arcuate growth lines; the last whorl is a tapering cone, nearly smooth, except for the faint spirals about its lower one-third; the aperture is narrow, straight, with a thin arcuate outer lip.

Height 45, diameter 21, aperture 33 mm.

This shell belong to the *Conus consobrinus* group, agreeing in its form and strongly nodulated spire whorls. The main difference is that *toroensis* is nearly smooth, the spirals showing only on the lower one-third, while *consobrinus* has most of the last whorl covered with beaded spirls.

Gatun Stage: Toro Cays.

Conus (Chelyconus) tortuosostriatus Toula Plate 1, figure 15

Conus (*Chelyconus*) *tortuosostriatus* Toula, 1911, Jahrb. der K-K. Geol. Riechsandstalt, Wien, vol. 61, p. 508, pl. 31, fig. 22.

Conus (*Hemiconus*) *tortuosostriatus* Cossmann, 1913, Jour. de Conchyliologie, vol, 61, p. 40, pl. 3, figs. 28, 29.

Conus tortuosostriatus Maury, 1917, Bull. Amer. Pal., vol. 5, p. 205, pl. 6, fig. 9

This shell should probably be considered as a short variety of *gracilissimus* Guppy, differing chiefly in its broader form and shorter spire.

The body-whorl is sculptured with about 24 raised, even, spiral cords, separated by deep, even interspaces. These interspaces are crossed by neat, incised lines, corresponding to the lines of growth. The nucleus consists of about 3, long, tapering smooth whorls, after which follow several turns of carinated and finely coronated post-nuclear whorls.

Length 22, breadth 9 mm.

Gatun Stage: Bocas del Toro.

Conus granozonatus Guppy Plate 3, fig. 15

Conus granozonatus Guppy, 1866, Jour. Geol. Soc. London, vol. 22, p. 287, pl. 16, fig. 5.

This is a rare species in Costa Rica, our collection containing only a single specimen from the Gatun beds of the Rio Blanco. It is characterized by a rather high, conic spire, with smooth or only slightly coronated whorls. The last whorl has about 18, wide, spiral bands, which are heavily granulated above. The specimen agrees well with Guppy's figure of the Jamaican shell.

Length 25, breadth 11 mm.

Gatun Stage: Rio Blanco, C. R.

Conus planiliratus Sowerby Plate 3, figures 10, 13

Conus planiliratus Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 44.

Conus planiliratus Guppy, 1866, *Idem.* vol. 22, p. 287, pl. 16, figure 7,

Conus planiliratus Gabb, 1873, Trans. Amer. Phil. Soc., p. 230, in part.

Conus planiliratus Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 528.

Conus planiliratus Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1583.

Couus planiliratus Cossmann, Jour. de Conchyliologie, vol. 61, p. 48, pl. 3, figs. 25, 26, 27.

Conus regularis Gabb, Jour. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 359, pl. 46, figs. 45-48. Not of Sowerby.

Conus planiliratus Maury, Bull. Amer. Pal., vol. 5, p. 209, pl. 7, fig. 10.

The occurrence of this species in Costa Rica is limited to the coral limestones of Limon, Gabb had specimens from here which he identified with the recent West Coast *Conus regularis* of Sowerby. The Limon shells agree very well with Guppy's figure in the Quarterly Journal and with Cossmann's figures of Bowden and Mindi specimens. The species appears to be closely

related to the recent *Conus Stimpsoni* Dall from the Florida Straits. (Proc. U. S. Nat. Mus., vol. 24, p. 503, pl. 29, fig. 7, 1903).

Surface of whorls are heavily sculptured with 25, 30 or more subequal spiral cords. Upper surface of whorls, flat or slightly concave and with 3 or more spirals. The shoulder is sharp and bounds a rather high, conic spire.

Length 31, breadth 16 mm.

Gatun Stage: Port Limon.

Conus planiliratus, var. **bocasensis**, n. var. Plate 3, fig. 14, 16

Shell of medium size, solid with a broad, stubby outline; spire low, conic with nearly straight sides and composed of seven or more whorls; the 1st 4 or 5 post-nuclear whorls are coronated; spire-whorls with 3 faint spirals and curved growth-lines; body-whorl large and wide, with 25 strong but somewhat irregular simple spiral cords; their interspaces are wide and with crowded, raised lines of growth and sometimes intercalated spirals; anterior canal nearly straight.

Length 32, breadth 17 mm.

This Cone, which should probably be considered as distinct, is fairly common in the shale beds, belonging to the Gatun Stage on Bocas Island. From typical *planiliratus* it differs in its broad stubby form and coarse sculpturing.

Gatun Stage: Bocas del Toro, Panama.

Conus marginatus Sowerby Plate 1, fig. 20

Conus marginatus Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 44.

Canus marginatus Gabb, 1873, Trans. Amer. Phil. Soc., vol. 16, p. 230.

Conus marginatus Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 528, pl. 29, fig. 5.

Conus marginatus Maury, 1917, Bull. Amer. Pal., vol. 5, p. 210, pl. 7, fig. 11.

On the basis of Guppy's figure in the Quarterly Journal, this cone is seen to belong to the type exemplified by the recent *C. verrucosus*, with its sulcated sides and appressed or beveled shoulder angle. Our collection contains a single specimen from Zone 5 of Red Cliff Creek which is very close to Guppy's figure Cossmann's specimen of *marginatus* from Martinique should probably be referred to some other species.

Gatun Stage: Zone 5, Red Cliff Creek, C. R.

Conus gracilissimus Guppy Plate 1, figure 14

Conus gracilissimus Guppy, 1866, Quart, Jour. Geol. Soc. London, vol. 22, p. 288, pl. 16, fig. 4.

Conus Orbignyi Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 230, Not *C. Orbignyi* Audouin, 1830.

Conus gracilissimus Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 527.

Conus gracilissimus Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1583.

Conus gracilissimus Cossmann, 1913, Jour. de Conchyliologie, vol. 61, pl. 4, fig. 13.

Conus gracilissimus Maury, 1917, Bull. Amer. Pal., vol. 5, p. 204, pl. 6, figs. 8.

A small, but long and slender cone, sulcated with 25 or more, strong, regular spiral cords. The spire is long and slender with slightly coronated whorls and the area between the sutures is delicately decussated by 3 or more spirals crossed by the raised and arcuated lines of growth.

Our collection contains specimens from Bocas and Limon, the largest measuring 26 by 9 mm.

Gatun Stage: Bocas del Toro, Pan., Port Limon, C. R.

Conus Burckhardti Bose Plate 3, figures 4, 5

Conus Burckhardti Bose, 1906, Bull. de Inst. Geol. de Mexico, numero 22, p. 50, pl. 5, figs. 39, 40.

Shell of moderate size, with a rather high slightly concave spire and long, acute apex; sutural whorls smooth, except for the

faint arcuate lines of growth and very indistinct spirals; the earlier whorls have a carinated suture but are only very faintly coronated; last whorl heavily sculptured with about 20, wide, even spiral bands, separated by grooves of about 1-3 of their width; these grooves are faintly incised by the longitudinal lines of growth; the spiral bands are slightly wider above and smooth, becoming granulated on the canal; this granulation appears on the posterior side of the bands only; aperture long and narrow.

Length 36, diameter 14.5 mm.
33 (apex broken) diameter 15 mm.

The original specimen of *Conus Burckhardti* was described from the Miocene of Mexico, State of Oaxaca. Our specimens from Panama and Costa Rica are a little larger, but show the characteristic high, smooth, spire and strong, flat, spiral bands of the body-whorl.

Conus tortuosopunctatus Toula is a similiar but smaller species. The difference in sculpture of the two species may be seen in the accompanying figures, the spiral bands of *tortuosopunctatus* being double or incised, while in *Burckhardti*, they are broad and simple.

Gatun Stage: Water Cay, Panama.
Zone 2, East Grape Point Creek.

Conus Harrisi, n. sp. Plate 3, fig. 1

Shell of moderate size, subcylindric with a high, even, conic spire; spire-whorls about 6 plus, flat, with close sutures, except for the upper whorls which are slightly carinate; the surface of the spire-whorls is nearly smooth, except for a few faint spirals; the last or body whorl is strongly sculptured with widely spaced and sub-regular grooves; these grooves form about 14 wide, spiral bands about the lower 3-4th of the last whorl; the upper 4th below the shoulder angle forms a wide, smooth band; below, the spiral bands are generally smooth except those about the lower

half of the shell, which may become, mesially divided and bear a few small granulations or beads about their upper half; aperture sublinear.

Height 51, diameter 23 mm

A single specimen of this elegant species was collected from the Gatun of the Banana River. It is a species of the *Conus Burckhardti* type but much larger and when perfect reaching a length of nearly 60 mm. The sculpture is of wide bands formed by deep, and regularly spaced grooves about the lower 3-4ths of the shell.

Gatun Stage: Hill No. 3, Banana River.

Conus multistriatus Bose Plate 1, figures 21, 23

Conus Agassizi Dall, variey *multistriatus* Bose, 1906, Bull. de Inst. Geol. de Mexico, numero 22, p. 49, pl. 5, figs. 34-38.

Conus gaza Johnson and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, pl. 23, figs. 2, 3.

Conus gaza Maury, 1917, Bull. Amer. Pal., vol. 5, p. 210, pl. 7 fig. 12.

This is the *Conus gaza* of Johnson and Pilsbry described from the Miocene of Santo Domingo and the Isthmus. It is a small, pretty species, recognized by its nearly biconic outlines and neat sculpture. The spire is high; with nearly smooth, spire-whorls and carinated sutures. The last whorl is rather short and heavily sulcated with about 18, regular, spiral cords, separated by intervals of their own width.

All our specimens come from Water Cay, where the species is fairly abundant. The largest specimen measures 20 by 11 mm. Bose's original specimens are from the Miocene of the State of Oaxaca, Mexico. They are somewhat larger, measuring 28 by 15 mm.

Gatun Stage: Water Cay.

Conus tortuosopunctatus Toula Plate 3, figures 6, 11

Conus tortuosopunctatus Toula, 1911, Jahrb. der K-K. Geol. Reichsanstalt, Wien, vol. 61, p. 507, pl. 31, fig. 21.

Shell small, with a high smooth, conic spire of about 12 whorls the earlier post-nuclear whorls are finely nodulated, the succeeding have the sutures carinated and then simple; body-whorl with 20 or more strong, beaded, spiral cords; three spiral cords are usually double or incised with a median line, especially on the anterior canal; the beading of the spiral cords is developed best on their posterior portions; interspaces of the cords nearly as wide as the cords themselves, smooth or with faint, longitudinal lines and frequently a small median spiral.

Length 30, breadth 13 mm.

Gatun Stage: Mt. Hope.

FAMILY TURRITIDÆ

Genus **TURRICULA** Schumacher

SECTION SURCULA H. AND A. ADAMS

Turricula lavinoides, n. sp. Plate 4, figure 6

Shell rather large and moderately solid; whorls about 12 in number, heavily sculptured with ribs and spiral cords; nucleus of two smooth, slightly bulbous whorls; post-nuclear whorls increasing uniformily in size; concave above, widest below the periphery; suture strongly appressed with a spiral cord in front of it; anal fasciole flat or concave, appearing nearly smooth except for about three, small, widely spaced spirals; remainder of whorls strongly sculptured with 8 or 12 axial ribs which are lacking from the anal fasciole and from the base of the last whorl; spiral sculpture of 3 or 4 strong cords on the spire-whorls, becoming 10 or more on the last whorl in addition to those of the anterior canal; finer, intercalated threads are present between the main spiral cords on the later whorls; the interval between the spirals is finely, longitudinally striated by long growth lines; anterior canal long and nearly straight, slightly calloused along

the inner lip, outer lip thin, with a shallow anal sinus lying in the sutural fasciole.

Length 54, diameter 20, last whorl 38 mm.

This elegant species may be compared with the *T. aspersa* Sowerby from the Santo Domingan Miocene and the recent *T. incisula* Dall from the West Coast of Mexico. The Dominican species lacks the sutural cord, as well as differing in details of its sculpture. *T. lavinoides* appears to be more closely related, differing in its finer sculpture and proportions.

Gatun Stage: Hill 12, Banana River.

Turricula lavinoides var. **limonensis**, n. var. Plate 4, figure 12

Shell of medium size and with about 10 whorls, nuclear whorls about 2 in number, at first smooth, becoming finely ribbed on the last half; post-nuclear whorls spirally and axially sculptured; anal fasciole concave, smooth, with a strong spiral cord just in front of the appressed suture; axial sculpture of about 8 sharp or rounded ribs on the periphery of each whorl, lacking entirely from the anal fasciole and from the base of the last whorl; spiral sculpture of 3 cords on the early spire whorls, becoming more numerous on the later; due to the intercalation of additional spirals, on the last whorl the spirals number about 22, including those on the canal; anterior canal long and straight; anal sinus shallow; outer lip thin.

Length 47, diameter 18, last whorl, 32 mm.
" 37 " 27 " 47

This shell when full-grown appears distinct from the *lavinoides* but young specimens cannot be easily separated. This variety differs from the typical form, by its sharp, narrow, and widely spaced axial ribs, which produce a sharp, angled, but not rounded shoulder to the periphery of each whorl. The anal fasciole is also wider and more smooth.

Gatun Stage: Toro Cays, Port Limon, coralline limestones.

Turricula taurina, n. sp. Plate 5, figure 3

Shell small, slender and fusiform; nucleus of nearly two smooth, convex whorls; post-nuclear whorls about seven; sutures appressed and bordered by a spiral cord; fasciole about one-half the width of the spire-whorls, smooth; the sculpture of the whorls is spiral, axial ribs lacking; on the spire-whorls there are four raised spiral cords with the flattened interspaces about three times the width of the spirals themselves; on the last whorl and anterior canal, there are 18 or 19 spirals; anterior canal, long, slender and strongly twisted or curved; outer lip simple; anal sinus as indicated by the growth lines is wide, moderately deep and occupies the middle of the fasciole.

Length 25, diameter 8, last whorl 16 mm.

This is a small and delicate species, characterized by its slender, fusiform outlines and lack of an axial sculpture. The spirals are narrow, raised cords, rather widely spaced. The single specimen was collected at Bocas del Toro.

Gatun Stage: Bocas del Toro, Panama.

Turricula Terryi, n. sp. Plate 5, figure 4

Shell small, slender and fusiform, with a long, evenly tapering spire and slender, twisted anterior canal; nucleus of two, smooth, small whorls, followed by 8 sculptured post-nuclear; suture appressed, bordered by a low, but wide, spiral cord; upper half or more of each spire-whorl, flat or slightly concave and forms the fasciole; fasciole nearly smooth or sculptured with few, low, faint spirals; early spire-whorls strongly sculptured with 12 or 13 axial ribs which are most heavy on the periphery of each whorl; these ribs become progressively weaker and on the last whorl are only feebly developed on the shoulder or periphery; spiral sculpture persistant but weak, consisting on the spire-whorls of 4 cords on the lower half, alternating with much weaker spirals; the fasciole as already noted is nearly smooth, or very weakly spiralled; on the last whorl, there are 20 spirals, includ

ing those on the anterior canal; aperture elliptical with a thin outer lip and long twisted anterior canal.

Length 23.5, diameter 7, last whorl 15 mm.

The small exposure of Gatun shales, on the east shore of Columbus Island, about one mile north of the city of Bocas del Toro, has yielded a large number of small interesting gastropods. More than a dozen species of Pleurotomids were collected at this place by Mr. R. A. Terry and the writer during a short period of collecting.

The *T. taurina*, also from this locality, is somewhat similiar but differs by its more convex whorls, deeper fasciole and pratically lacks all axial sculpturing.

Gatun Stage: Bocas del Toro, Panama.

Genus **TURRIS** Bolton

Turris albida Perry — Plate 4, figres 1, 2

Pleurotoma albida Perry, 1811, Conch. Expl., pl. 32, fig. 4.
Pleurotoma virgo Lamarck, 1822, An. s. Vert., vol. 7, p. 94.
Pleurotoma haitensis Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 50.
Pleurotoma virgo Moore, 1853, Quart. Jour. Geol. Soc. Lond., vol. 9, p. 130.
Pleurotoma barretti Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 290, pl. 17, fig. 6.
Pleurotoma antillarum Crosse, 1865, Journal de Conchyliologie, vol. 13, p. 34, pl. 1, fig. 8. Not of d'Orbigny.
Turris (*Surcula*) *virgo* Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, pp. 206, 207.
Pleurotoma albida Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p. 28, pl. 4, figs.8a.
Pleurotoma albida Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 343.
Pleurotoma haitensis Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 16, pl. 2, figs. 1-4.
Pleurotoma cf. *antillarum* Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 18, pl. 2, figs. 5, 6.
Turris albida Dall, 1915, Bull. 90, U. S. Nat. Museum, p. 38, pl. 5, fig. 13, pl. 14, fig. 7.

Turris albida Maury, 1917, Bull. Amer. Pal., vol. 5, p. 214, pl. 8, figs. 4-8.

This is a common species in the Gatun beds of Central America. The usual form is a large, strongly sculptured and shoulder shell, which corresponds best to the variety described by Guppy from Jamaica as *barretti*. Our largest specimen from Toro Cays, Panama measures as follows: Length 86, diameter 27, last whorl 56 mm. *T. albida*, is also a common fossil in the Miocene of Santo Domingo, Jamaica, Trinidad and Venezuela. Its geologlcal range is from the Oligocene to the recent.

Gatun Stage: Gatun, C. Z.
Toro Cay, Water Cay, Panama.

Genus **LEUCOSYRINX** Dall

Leucosyrinx chloris, n. sp. Plate 5, fignre 19

Shell subfusiform, thin, with an acute spire and a long, straight, anterior canal; nucleus small, globular of about 2, smooth, convex whorls; post-nuclear whorls about 7; the spire-whorls are strongly angled in the middle, leaving a wide, concave or sloping zone about the upper suture; the sculpture consists of small, more or less confluent tubercles on the periphery of the whorls and number on the last whorl about 14; in addition, the whole surface is strongly sculptured with raised, subequal, spiral threads; base strongly contracted to the long, straight, anterior canal; the outer lip is broken; anal sinus, as indicated by the growth lines, lies in the concave zone, close to the upper suture.

Length 14.50, diameter 5.00, aperture 7.25 mm.

This appears to be a true *Leucosyrinx*, characterized by its thin shell, long, anterior canal and acute spire. It occurs in the Bocas shales with *Drillia lithocolletoides*, *cocosina*, *Terebra benthalis* var. *bocasensis* and others, shells which are all closely related to recent deep-water species.

Gatun Stage: Bocas del Toro.

Genus **ANCISTROSYRINX** Dall

Ancistrosyrinx elegans Dall, variety — Plate 4, figure 17

Ancistrosyrinx elegans Dall, 1881, Bull. Museum Comp. Zool., vol. 9, p. 54.

Ancistrosyrinx elegans Dall, 1889, Bull. Museum Comp. Zool., vol. 18, pt. 2, p. 78, pl. 38, fig. 3.

The discovery of this elegant, recent species in the Gatun beds of Costa Rica is of more than usual interest, the record being based on a single, small but otherwise quite typical specimen from Hill 1a of the Banana River. Comparison with Dall's figure in the Blake Report, shows no important difference, except that the sculpture of the fossil shell is somewhat finer.

A. elegans, is recorded by Dall from the Florida Reefs and from 805 fathoms of water off Havana, Cuba.

The dimensions of our shell is as follows: Length 15, diameter 5.75, last whorl 11 mm.

Gatun Stage: Hill 1a, Banana River.

Ancistrosyrinx Dalli, n. sp. — Plate 4, figure 16

Shell larger than the preceding and very nearly smooth; nucleus very small and smooth; post-nuclear whorls seven or more with a large and prominent, dentate or spinous keel; between the keel and the suture, there is a wide, nearly flat area, which carries a strong, smooth, median, spiral cord, behind which lies the small concave anal fasciole; the rest of the shell is smooth and without spirals;on the last whorl, the peripheral keel carries about 18 short, broad, spiny teeth; the canal is long, slender and straight; outer lip thin and fragile.

Length 14, diameter 7, last whorl 9.5 mm.
20 10, 15 mm.

Two specimens are represented in our collection, and the smaller but more perfect specimen is selected as the Holotype. It differs from the described species of *Ancistrosyrinx* by its

nearly total lack of spiral sculpturing. The species is named for Dr. W. H. Dall of the National Museum, the author of the genus *Ancistrosyrinx*.

Gatun Stage: Toro Cay, Water Cay, Panama.

Genus **DRILLIA** Gray

Drillia venusta, Sowerby — Plate 4, figure 9

Pleurotoma venusta Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 50, pl. 10, fig. 7.

Pleurotoma venustum, Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 289.

Turris (*Drillia*) *venusta*, Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 208.

Pleurotoma venusta, Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 527.

Pleurotoma venusta, Guppy and Dall, 1896, Proc. U. S. Nat. Museum, vol. 19, p. 305.

Drillia venusta Maury, 1917. Bull. Amer. Pal., vol. 5, p. 216, pl. 8, figs. 13, 14.

The *Drillia venusta* and *consors* of Sowerby, are the two commonest Pleurotomids in the Gatun beds of Costa Rica. Both are characterized by a neat, regular and reticulate sculpture of spirals and axial ribs. In *venusta*, the anal fasciole is narrow, and appears as a deep constricted zone, encircling the upper part of each whorl. The spirals are narrow bands, produced between deep, incised lines and in typical specimens number on the last whorl about 18. The canal is rather long and usually more or less twisted.

Drillia venusta, occurs also in the Miocene of Jamaica, Trinidad and in Santo Domingo.

Gatun Stage: Gatun, C. Z.
Banana River, Port Limon.

Drillia consors, Sowerby — Plate 4, figures 8, 10, 13

Pleurotoma consors, Sowerby, 1849, Quart. Jour. Geol. Soc. London, vol. 6, p. 50.

Pleurotoma consora, Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 280.

Turris (*Drillia*) *militaris*, Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 207. Not of Hinds, 1843.

Pleurotoma consors, Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 527.

Drillia militaris, Gabb, 1881, Jour. Acad. Nat. Sci. Phila., vol. 8, and series, p. 337.

Pleurotoma alesidota, Dall, var. *magma* Bose, 1908, Bol. Inst. Geol de Mexico, No. 22, p. 47, pl. 5, figs. 30, 31, 33, 45,

Pleurotama sp. aff. *Pl. alesidota* (Dall) var. *macilenta* Toula, 1911, Jahrb. der K-K Geol. Reichsanstalt Wien, vol. 61, p. 506, pl, 30, fig. 11. Not *alesidota* or *macilenta* Dall, 1889.

Drillia consors Brown and Pilsbry, 1911, Proc. Acad Nat. Sci. Phila., vol. 63, p. 345.

Drillia consors, Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 20, pl. 2, figs. 8-14.

Drillia consors, Maury, 1917, Bull. Amer. Pal., vol. 5, p. 216, pl. 8, figs. 15, 16.

This species is easily distinguished from the *venusta*, by its more slender form, wide but shallow anal fasciole, sharper sculpture and straight, longer, anterior canal. The most common variety, illustrated by figure 10, averages in length about 35 mm. The axial ribs are numerous (about 28), straight or slightly oblique and only slightly heavier than the raised spiral cords. In addition the surface is overrun by fine and almost microscopic spirals. Figure 8 of a large variety from Grape Point, has about 9 whorls and measures 60 mm in length. The early spire-whorls have the usual sculpture as seen on typical *consors*. On about the seventh whorl, the ribe increase suddenly to nearly twice their normal number. They gradually become obsolete, so that on the last whorl, pratically only the spirals are left. The fine, microscopic spirals seen on typical *consors* are lacking.

The *Drillia alesidota* and its variety *macilenta* Dall of the recent West Indian fauna, are closely related to *consors*.

Gatun Stage: Mt. Hope, C. Z.
Banana River, Port Limon.
Boras.

Drillia cf. moensis, Gabb

Drillia moensis, Gabb, 1881, Jour. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 351, pl. 46, fig. 33.

A single small speimen of a *Drillia* was collected from the coral limestones near Limon, which agrees partly with Gabb's figure and description. Our specimen has 7 instead of 8 ribs, and lacks the sutural spiral mentioned by Gabb. The dimensions of this shell are: Length 12.5, diameter 4.5, last whorl 7 mm.

Gatun Stage: Port Limon.

Drillia papaya, n. sp. Plate 4, figure 5

Shell of medium size, slender and subfusiform; whorls 10 (mucleus eroded); anal fasciole, a deep concave zone, occupying about 1-3 of a whorl interval and bordered above by a small sutaral cord; sculpture of heavy, knob-like ribs, crossed by spiral threads of different strengths; axial ribs about 6 on the last whorl, lacking from the fasciole and from the base and anterior canal; spiral sculpture of primary secondary and tertiary threads, there being about four primary threads on each spire-whorl, on the last whorl there are 8 or more primary threads, with an intermediate secondary and finer tertiary threads on each side; the anterior canal has numerous threads of varying strength; aperture long and subelliptical; anterior canal long and slightly bent backwards; anal sinus as indicated by the growth lines is deep and wide.

Length 32, diameter 10, last whorl 19 mm.

A single specimen was collected from certain sandstones of Lower Gatun age from a small tributary stream of the Rio Cocles near Old Harbor, C. R. The recent *Drillia haliostrephis* Dall from the Gulf of Mexico appears closely related, but the fos-

sil shell has a more slender spire and slightly longer anterior canal.

Gatun Stage: Rio Cocles, C. R.

Drillia coccos, n. sp. Plate 5, figure 7

Shell small, slender and fusiform; whorls 10 or more, nucleus eroded; fasciole deep and concave, about ½ of the width of a spire-whorl, bordered above by a strong sutural cord, otherwise smooth; sculpture of strong axial ribs, which are lacking from the fasciole and from the base of the last whorl; these ribs number on the last whorl about 10; the ribs are crossed by strong, raised cord-like spirals, there being at first 2 on the earliest spire-whorls and on the later 3; the last whorl shows 8 spirals and the wide interspaces are occupied by 3 or more smaller ones; additional and more crowded spirals occur on the long slender canal; anterior canal long and slender, slightly bent.

Length 21, diameter 6, last whorl 12 mm.

A small, very slender and fusoid species with strong, persistent spiral and axial sculpture. A single specimen was collected at Coco Plum, a small cocoanut plantation about 40 miles east of Bocas del Toro.

Gatun Stage: Coco Plum.

Drillia chiriquiensis, n. sp. Plate 5, figure 2

Shell solid of medium size; whorls 7 (apex lost), of slightly convex profile; anal fasciole small but quite deep and nearly smooth; suture strongly appressed and bordered just below by a strong, elevated spiral cord; sculpture of numerous, somewhat oblique riblets and numerous weak spirals; the ribs commence at the lower edge of the fasciole, pass slightly obliquely across the whorls to the suture or on the last whorl across the base to the canal; the ribs on the last whorl number 15 or 16; spirals of numerous weak threads which are generally alernating in character; the spirals are very small on the fasciole, quite large and

coarse on the anterior canal; the outer lip is heavily thickened by a large rib; anterior canal short and bent.

Length 25, diameter 8, last whorl 15 mm.

A single shell from Bocas, serves as type for this species. It recalls the *D. consors* Sowerby, but differs in its much finer sculpture.

Gatun Sage: Bocas del Toro, Panama.

Drillia citria, n. sp. Plate 5, figures 12, 13

Shell small; whorls about 8, of which the first 2 belong to the small, obtuse, smooth nucleus; the post-nuclear whorls are strongly sculptured with ribe and spirals; the upper 1-3 of the spire-whorls carries a concave fasciole, bordered posteriorly by a strong sutural cord to the 1st post-nuclear whorl; the fasciole is smooth or only faintly sculptured with fine spirals; the sculpture consists on the last whorl of about 9 ribs which fade out rapidly on the base and on the fasciole; the ribs are crossed on the early spire-whorls by 2 spiral cords, becoming 3 on the later; on the last whorl there are 12 more of which 6 are on the anterior canal; the intervals between the spirals, are 3 or more times as wide as the spirals themselves and are sculptured with fine spirals threads; aperture sub-elliptical, with a short and slightly twisted anterior canal; anal sinus moderate.

Height 11, diameter 4 mm.

A small species, common in the coralline phase of the Gatun at Port Limon.

Gatun Stage: Port Limon.

Drillia aquanica, n. sp. Plate 5, figures 16, 17

Shell small, slender with a long spire and a shorter last whorl; whorls about 11, the nucleus composed of 2 small, smooth convex whorls and about 9 post-nuclear; whorls strongly sculptured with ribs and spiral cords; fasciole nearly 1-3 the width of the spire-whorls, marked with fine spirals and bordered posteri-

orly by a strong sutural cord; the spiral sculpture consists on the early whorls of 2, later 3 and finely 4 cords on the penultimate whorls; the last whorl has 8 spiral cords and 10 others on the canal; the spiral cords are separated by interspaces of slightly greater width; the interspaces are finely striated with small spiral threads; the axial sculpture consists of about 9 knot-like ribs over which pass the enlarged spiral cords; the ribs pass over the base of the last whorl to the canal and slightly over the facciole; aperture elliptical with a short, straight canal.

Height 18, diameter 6, last whorl 9 mm.

This is a diminutive of *Drillia fusiformis* of the Miocene of Santo Domingo, the two species having practically the same sculpture. *Drillia fusiformis* of 11 whorls measures 35 mm in length, while *aquanica* of the same number of whorls has a length of only 19 mm. The Maury collection contains a small but quite typical specimen of *aquanica* from the Rio Gurabo, Santo Domingo.

Gatun Stage: Water Cay.

Drillia limonica, n. sp. Plate 4, figure 15

In general form like *Drillia consors* Sowerby, with a long spire and but slightly shorter anterior canal; whorls about 8½ of which 1½ belongs to the small, smooth, blunt nucleus; the post-nuclear whorls are sculptured with ribs and weaker spirals; on the 1st three whorls, the anal fasciole is but slightly differentiated; it increases slowly in strength until on the later whorls it has become a concave zone as in *consors*; a sutural cord is introduced on the 2nd post-nuclear whorl and is present on all the succeeding whorls; on the spire-whorls there are about 11, widely spaced ribs; these ribs are lacking from the anal fasciole, except on the very earlest whorls, where they are faintly continued towards the upper sutures; on the last whorls, the ribs are smaller and number about 13; between these main ribe on the last whorl there appear occasionally smaller and shorter ribs which do not reach to the edge of the fasciole; there are 5 faint spirals

crossing the ribs on the spire-whorls and very much finer ones in the anal fasciole; the last whorl shows about 10 spirals together with others on the canal; aperture elongate with the anterior canal rather long and straight.

Length 19, diameter 6.5 mm.

Like the *Drillia consors* in form, this species is distinguished by its fewer ribs and shallower anal faciole. The ribs on the earlier whorls are oblique, but become very nearly straight and vertical on the later.

Gatun Stage: Port Limon.

Drillia bocatoroensis, n. sp. Plate 5, figure 6

Shell of medium size, solid and strongly sculptured with ribs and spirals; whorls about 11, the nucleus eroded in the type specimen; fasciole occupying about 1-3 of the width of the spire-whorl, with a large sutural cord above which the edge of the suture is finely and regularly beaded or granulated; the surface of the fasciole is slightly undulated by the obsolete ends of the ribs, otherwise smooth; axial ribs about 8 on the last whorl, straight and nearly in line across the face of the spire-whorls to the apex, but interrupted and lacking from each fasciole; spiral sculpture of the few raised cords with wider interspaces; there are 3 spirals on the spire-whorls, about 6 on the last, with 9 more on the anterior canal; the interspaces in addition carry fine and submicroscopic spiral lines; the base of the last whorl is somewhat constricted with a short anterior canal.

Length 23, diameter 8, last whorl 13.5 mm.

From the several species of fusoid Pleurotomids in the Gatun beds of Panama and Costa Rica, this species differs in its heavy, persistent ribs and sharp spiral sculpturing. The fasciole is nearly smooth, bordered above by a heavy sutural cord.

Gatun Stage: Bocas del Toro.

Drillia theobroma, n. sp. Plate 5, figure 11

Shell subfusiform; whorl 7 (apex broken); fasciole a narrow, concave zone, not strongly differentiated from the rest of the whorl, spirally sculptured and bordered above on the early spire-whorls by a sutural cord; sculpture consists on the spire-whorl of about 10 low ribs, becoming more numerous and subobsolete on the last; the spiral sculpture consists of raised, alternating, revolving cords; there are 2 or 3 spiral cords on the early spire-whorl, becoming 5 or more on the later; the last whorl has about 10 spirals in addition to those on the anterior canal; between each pair of the main or primary spirals there is a smaller, secondary spiral; base rounded or contracted to the slender anterior canal.

Length 21, diameter 7.5, last whorl 13 mm.

It is possible that this species, belongs to the genus *Glyphostoma*, as the type specimen seems to show a slightly thickened and inflated outer lip. The aperture is however so completely filled with a rocky matrix, that this observation cannot be fully verified. The axial sculpture is practically lacking from the last whorl, leaving a surface simply marked with the rough spirals.

Gatun Stage: Bocas del Toro.

Drillia aurantia, n. sp. Plate 5, figure 15

Shell small, solid; whorls about 9; the nucleus consists of about 1½ smooth, convex whorls which through the gradual introduction of the ribs, followed by the spirals blend in with the post-nuclear whorls; the anal fasciole is rather wide (about 1-3 of the spire-whorl) and shallow; it appears very early and carries from the start a strong, sutural cord; the sculpture consists of numerous closely spaced, linear ribs which are absent from the anal fasciole; these ribs number on the last whorl about 21; the spirals are uneven threads which are strongest below and on the base; the fasciole also carries one or more fine threads except

on the base of the last whorl; the spirals do not cross the ribs so that the summit of the ribs are left nearly smooth; aperture small with a short, slightly twisted anterior canal.

Length 11, diameter 4 mm.

A small species sculptured like the *D. elegans* Conrad of the Chesapeake Miocene of Virginia, but with more numerous and more closely spaced ribs.

Gatun Stage: Port Limon.

Drillia musacina, n. sp. Plate 5, figures 27, 28

Shell small, slender; the nucleus of about 2 whorls, the 1st blunt, convex and smooth, followed by the 2nd which is strongly carinate; there are 7 post-nuclear whorls of slightly convex profile; the fasciole is a narrow band on which the ends of the ribs become strongly deflected to the left; the axial sculpture of about 16, narrow ribs on the last whorl; the ribs are continuous across the spire-whorls to the upper sutures but become bent and strongly deflected on the fasciole; on the last whorl, the ribs are continued to the base of the canal; the spirals vary somewhat in strength but are usually subregular spiral bands of which there are 7 or 8 on the spire whorls and about 14 on the last whorl and the canal; the back of the last whorl is strongly humped; the outer lip was probably thin (broken in all our specimens); canal short, straight.

Length 9, diameter 2.75, last whorl 5.00 mm.

A small species abundant in the Gatun beds of the Banana River.

Gatun Stage: Hill 1a, Banana River.
Hill 3, Banana River.

Drillia estrellana, n. sp. Plate 10, figures 31, 32

Shell very small, solid, porcellaneous; slender with a long spire and a short body-whorl; nucleus small of 2 smooth, convex

whorls; post-nuclear whorls about 7; sculpture with strong ribs and impressed spiral lines in their interspaces; the anal fasciole is a constricted band about the upper 1-4 of the whorl and which passing over the ends of the ribs dislocates them as in *Terebra;* there are 11 ribs on the last whorl which commencing at the upper suture pass across the sutural fasciole but somewhat diminished in strength, continue across the face of the whorl in a slightly oblique direction to the columellar region; the summits of the ribs are smooth but the interspaces are sculptured with impressed lines produced by spiral bands of regular width; there are 4 such bands on the spiral-whorls and about 12 on the last whorl, including a few on the canal; aperture small, subelliptical and a short twisted canal.

Height 7.5, diameter 1.75 mm.

A small species of Terebroid appearance, the ends of the ribs being strongly dislocated as they pass across the small anal fasciole.

Gatun Stage: Coll. 7, Estrella River.

Drillia limonetta, n. sp. Plate 5, figure 10

Shell small, solid, porcellaneous; whorls about 8, coarsely ribbed and polished; fasciole absent; the sculpture consists of moderately strong ribs which on the spire-whorls pass suture to suture but are only slightly flexed near the upper suture; on the last whorl, the ribs number about 11; the last rib is much enlarged and forms the outer lip; the ribs are but shortly continued upon the base and do not reach the canal; in addition, the surface is covered with fine, irregular threads which are nearly obsolete on the upper portions of the whorls but are strong on the base and on the canal; aperture subelliptical with a short canal, somewhat bent or excavated ventrally; anal sinus simply as a vertically directed notch at the junction of the outer lip with the body-whorl and is bordered by a tooth-like denticle on its inner side.

Length 12.25, diameter 5.00, last whorl 7.25 mm.

A small, solid and porcellaneous species, belonging to Dall's *Cymatosyrinx*. The sutural fasciole being absent, the ribs are continuous to the upper suture and the surface is finely striated with small, irregular spiral threads.

Gatun Stage: Port Limon.

Drillia carruca n. sp. Plate 4, figure 11

Shell of medium size, solid; whorls 7 plus (apex broken), rather rapidly tapering; no fasciole; axial sculpture of about 8, narrow ribs with deep and wider interspaces; the ribs commence at the top of the canal and pass across the whorls to the sutures; the ribs are nearly in line across the spire-whorls to the apex; spiral sculpture of slightly elevated cords, separated by wide, flat interspaces; there are about 7 spiral cords on the spire-whorl; with 12 on the last whorl; aperture sub-elliptical, the outer-lip somewhat thickened and a short canal.

Height 18, diameter 7.25, last whorl 11 mm.

This shell resembles *Drillia musa* in its general sculpture of fine, widely spaced, spiral cords.

Gatun Stage: Coll. 4, East Grape Point Creek.

Drillia limonensis, n. sp. Plate 5, figures 8, 9

Shell of medium size and in form recalling *D. venusta* Sowerby; nucleus of nearly three, smooth convex whorls; post-nuclear whorls 8; anal fasciole scarcely perceptible on the early whorls, becoming on the later, simply a narrow, constricted zone, bordering the suture; sculpture of rather numerous riblets, which are abruptly bent to the left near the posterior suture on crossing the constricted anal fasciole; three ribs number on the last whorl about 15; the spiral sculpture consists of very fine threads; the space between each pair of adjacent spiral threads is finely and microscopically decussated by the raised lines of growth, producing a shagreening of the whole surface; in mature shells, the last rib becomes unusually large and heavy, producing a large and strong-

ly thickened outer lip; canal short, slightly bent inward or outwards; callous on the inner lip.

Length 20, diameter 7.5, last whorl 11 mm.

The general form of this shell is that of *Drillia venusta* Sowerby, which it also recalls in its constricted anal fasciole. The whole surface appears minutely shagreened, an effect produced by the fine, sub-microscopic, spiral threads as well as a minute decussation of their interspace. This species is fairly abundant in certain sandy layers found intercalated in the hard and generally barren coral-reef limestone along the sea-front at Port Limon.

Gatun Stage: Port Limon.

Drillia Cristobali, n. sp. Plate 5, figure 1

Shell of the general form of *venusta*, rather solid; whorls 6, (apex broken in the type specimen); anal fasciole a narrow constricted zone, bordering the upper suture; no sutural cord: sculpture of numerous, straight, parallel ribs and fine spirals; ribs on the early whorls about 12, becoming about 19 on the last; on the anal fasciole, the ribs are shortly deflected or bent; spirals very numerous and on slight magnification seen to consist of narrow, even raised threads with interspaces of nearly twice the width of the spirals themselves; anterior canal rather short and slightly bent backwards; aperture sub-ellipitical with a thin outer lip; anal sinus small and shallow.

Length 20, diameter 8.5, last whorl 11.5 mm.

This species, like the *limonensis*, has the general form and constricted fasciole of *Drillia venusta* Sowerby, but differs by its smaller size, short canal and quite different spiral and axial sculpture. *D. limonensis*, is more closely related, but that species differs in its more slender form and peculiar submicroscopic sculpture.

The single specimen serving as the type, was collected from the Gatun shale, exposed about a mile north of the city of Bocas del Toro, on Columbus or Cristobal Island.

Gatun Stage: Bocas del Toro, Panama.

Drillia bocasensis, n. sp. Plate 5, figure 5

Shell of medium size, solid; nucleus of about 2 smooth whorls; post-nuclear whorls about 10; anal fasciole a narrow constricted zone, nearly filled with a large, sutural cord; axial sculpture of large, heavy ribs, about 9 on each whorl; the ribs pass from suture to suture and on the last whorl across the base to the anterior canal; a large, hump-like rib is developed on the back of the last whorl, formed during a resting stage; no spirals; the growth-lines produce a minute but characteristic sculpture of heavy, raised threads, which pass obliquely across the surface of the whorls and ribs, and follow the curve of the anal sinus across the fasciole; the sutural cord is finely granulated by the raised growth-lines; canal short but straight; outer lip large, with a deep anal sinus at its posterior union with the body-whorl.

Length 22, diameter 8, last whorl 12 mm.

This species should more properly be referred to the genus *Cymatosyrinx* Dall, based on the *Pleurotoma lunata* H. C. Lea, a Chesapeake Miocene fossil. The form and general sculpturing of *bocasensis* is similiar to that of many species of this group but it may be recognized at once by its very peculiar, submicroscopic sculpture formed by the close, heavy growth-lines.

Gatun Stage: Bocas del Toro.

Drillia aquaensis, n. sp. Plate 5, figure 25

Shell small and solid; nucleus of 1+ whorls (mostly broken on type specimen); post-nuclear whorls about 8; anal fasciole lacking; axial sculpture of about six, large, heavy and straight ribs, which pass from suture and across the base of the last whorl onto the anterior canal; each set of ribs is in a straight line from the canal across the spire-whorls to the apex; spiral sculpture of about 8 impressed lines which produce a series of flat but

quite wide, spiral bands; on the last whorl there are about 22 spiral bands; much finer near the suture, larger and wider on the middle of the whorl and on the canal; canal short and slightly bent to the left; inner lip calloused.

Length 15, diameter 5.5, last whorl 8.5 mm.

Characterized by its six axial ribs and finer sculpture of flat, spiral bands. It belongs to the genus *Cymatosyrinx* of Dall.

Gatun Stage: Water Cay, Panama.

Drillia musa, n. sp. Plate 5, figure 26

Shell about the same size as the preceding but with a more slender spire; nucleus of 2 smooth whorls (broken); post-nuclear whorls about 8; no fasciole; axial ribs about 9, pass from suture to suture and across the base to the anterior canal the ribs are in line across the whole series of spire-whorls; spiral sculpture quite heavy, consisting of raised threads with wider interspaces; the spirals number on the spire-whorls 8 or 9, and on the last whorl about 22; aperture large and suboval; anterior canal short, narrow and heavily calloused to form the inner lip.

Length 17; diameter 6, last whorl 9 mm.

Related to the preceding, but differs by its more slender form; with 9 instead of 6 ribs and a much coarser spiral sculpture.

Gatun Stage: Banana River, C. R.

Drillia lithocolletoides, n. sp. Plate 5, figure 18

Shell small, glassy or translucent; nucleus of about 3 smooth, convex and glassy whorls, followed by 6 post-nuclear whorls; the whorls are strongly angled in the middle by tubercular-like ribs but leaving a concave zone about the upper sutures which forms the anal fasciole; on the last whorl, the ribs or tubercles number 11; are set obliquely and on the back of the whorl, they are continued slightly over the base; the surface is smooth and polished; last whorl slightly constricted above the short, straight canal; aperture subovate.

Height 10.75, diameter 3.25 mm.

The *Drillia lithocolleta* Watson is a recent deep-water species, dredged by the Challenger and the Blake, at several stations in the West Indies and off the Florida coast, from depths of 400 to nearly 1000 fathoms. The Bocas shell seems to be very closely related to the recent species; differing only from Dall's figure in the Blake Report (plate 11, fig. 61), in being somewhat more slender, with heavier tubercles and a longer base.

Gatun Stage: Bocas del Toro.

Drillia cocosina, n, sp. Plate 5, figure 14

Shell small, glassy or translucent in texture; spire twice or more the length of the last whorl and the canal; whorls 8 plus, the earlier ones missing; no anal fasciole; the sculpture consists at first of a lower row of small tubercles, but a second or upper row soon begins to appear and on the last whorl, this upper set of tubercles is very nearly equal to the lower; the last whorl has about 13 of these tubercles, in addition the whorl is finely sculptured with fine, regular, closely spaced spiral threads which cover the entire whorl and the canal, but leaving the tops of the tubercles smooth; aperture ovate, with a short, twisted canal.

Length 12, diameter 3.5 mm.

This interesting species from the shales near the city of Bocas del Toro, is related to the recent *Drillia oleacina* Dall dredged from rather deep water in the Gulf of Mexico and elsewhere in the West Indies. In differs from that species in being less slender and with a larger body-whorl.

Gatun Sage: Bocas del Toro.

Genus GLYPHOSTOMA Gabb

Glpyhostoma dentifera, Gabb.

Glyphostoma dentifera Gabb, 1872, Proc. Acad. Nat. Sci. Phila., vol. 24, p. 270, pl. 11, fig. 4.

Glyphostoma dentifera Gabb, 1873, Trans. Amer. Phil. Soc. vol. 15, p. 210.

Glyphostoma dentifera Dall, 1889, Bull. Mus. Comp. Zool., vol. 18, pt. 2, p. 108.

Glyphostoma dentifera Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 31, pl. 2, figs. 15, 16, 17.

Glyphostoma dentifera Maury, 1917, Bull. Amer. Pal., vol. 5, p. 225, pl. 9, fig. 16.

A single specimen of this species was collected from the coralline phase of the Gatun, near Port Limon. The shell showing 5 whorls (apex lost), measures 18 by 8 mm. The pecular shagreening, characteristic of the genus is strong and easily seen.

This shell agrees closely with the figure given by Cossmann, based on a Dominican specimen. It differs in several respects from the specimen figured by Dr. Maury in her Dominican Fossils from a metatype, sent by Professor Gabb to the Cornell Museum. Dr. Maury's shell is larger, has a longer spire, and the microscopic shagreening is much finer.

Dall in the Blake Report, doubtfully refers to this species, an imperfect specimen collected in 15 fathoms of water at Sand Keys.

Gatun Stage: Port Limon.

Glyphostoma moinica, n. sp. Plate 5, figures 29, 30

Shell small, solid with a coarse, tuberculate, subreticulate sculpture and a thickened, enlarged onter lip; nucleus small, pointed and tapering of 3 or more, smooth, convex whorls followed by about 4 post-nuclear; the sculpture consists of about 14 narrow ribs continuous from the canal to the upper suture and crossed by even, spiral cords; their intersection form small

rounded beds or tubercles; immediately after the nucleus, there is but one spiral, soon followed by two and on the penultimate there are three; the last whorl has five spirals and three or four more on the canal; aperture elliptical with a large expanded outer lip, smooth within and a deep, anal sinus at its upper end; canal short and straight.

Height 5.75, diameter 2.75, last whorl 3.75 mm.

A small species doubtfully referred to *Glyphostoma*, having the outer lip smooth within and lacking the peculair, submicroscopic structure of typical *Glyphostoma*.

Its sculpture is coarse, the intersection of the ribs and spirals forming small beads or tubercles.

Gatun Stage: Port Limon.

Genus **CYTHARA** Schumacher

Cythara terminula var. **costaricensis**, n. var. Plate 5, figures 21, 22

cf. *Cythara terminula* Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p. 38, pl. 2, fig. 5.

The *Cythara terminula* Dall, to which the present shell appears closely related, was described from the Caloosahatchie beds of Florida, of Pliocene age. The Costa Rican shell with the same number of whorls is somewhat small (typical *terminula* of 7 whorls, 16 mm), (variety *costaricensis* 7 or 8 whorls, 13 mm), and has 8 instead of 9 ribs. The details of the spiral sculpturing is very similiar, consisting of flattened bands separated by sharp channels. The spiral bands carry a central incised line, which produce the appearance of being in pairs.

C. cercadica Maury from Santo Domingo, is a larger species with higher spire and simple and not banded spirals.

Length 13, diameter 5, last whorl 10 mm.

Gatun Stage: Hill 1a, Banana River.

Cytharella limata, n. sp. Plate 5, figure 20

Shell small, nearly smooth and porcellaneous; spire slightly

shorter than the narrow aperture; nucleus of about 3½ smooth, convex whorls, the last ½ turn being very finely and closely ribbed; there are 3½ post-nuclear whorls; sculpture consists of narrow, slightly oblique ribs which pass across the spire-whorls from suture to suture and on the last whorl follow down on the anterior canal to its tip; there are 8 ribs on the last whorl; the spaces between the ribs are wide, flat and smooth; the tops and sides of the ribs themselves are carved or etched with fine, subobsolete spiral lines; aperture linear-elliptical, the outer lip somewhat thickened by the last rib, but smooth within; anterior canal long straight.

Height 9, diameter 3.50, last whorl 7mm.

Gatun Stage: Port Limon.

Genus **BORSONIA** Bellardi

Borsonia cocoensis, n. sp. Plate 5, figures 23, 24

Shell small, biconic; whorls about 7; nucleus of 2; nearly smooth whorls, followed by 5 strongly shouldered post-nuclear whorls, the angle of which on the spire-whorls comes just above the lower suture; above the shoulder, the whorls are flat or slightly concave to the upper suture; sculpture with a double or triple beaded cord on the periphery and with alternating beaded spirals both above and below; on the last whorl, the primary spirals number 15 or 16, above the shoulder 3 or 4; the suture is bordered in front by a strong cord; pillar long, slightly twisted in front and with 2 sharp, plications; the anal sinus lies on the peripheral angle as in typical *Turris*.

Length 16, diameter 8, last whorl 11 mm.

The present species is based on two specimens from Coco Plum about 30 miles east of the city of Bocas del Toro. The *B. variosa* Sowerby from the Dominican Miocene, is a related species, differing in its porportionately longer spire.

Gatun Stage: Coco Plum.

Genus **SCOBINELLA** Conrad

Scobinella Morierei (Laville) Cossmann Plate 4, figures 3, 4

Euchilodon Morierei Laville, in Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 34, pl. 3, figs 6, 7.

Shell of medium size, with spire and last whorl of nearly equal lengths; sculpture of numerous, close, bead-like spiral cords, 3 or 4 on the spire-whorls, 18 or more on the last whorl and canal; the sutural fasciole is rather narrow, shallow and concave and with 4 much finer beaded cords; the suture is bordered in front by a heavy beaded spiral, which on the early spire-whorls, nearly fills the entire fasciole ; columella with four sharp folds, the largest above; canal nearly straight; aperture narrow, with a lirated outer lip.

Length 49, diameter 15, last whorl 33 mm.

This is one of the most elegantly sculptured Pleurotomoids in the Gatun beds of Panama and Costa Rica. Described by Laville and Cossmann from Mindi in the Canal Zone, we have in addition collected the species from Toro and Water Cay, (where it is fairly common), Bocas del Toro and from Limon. The predominating spiral sculpture and columellar folds are very suggestive of *Mitra*.

Gatun Stage: Mindi, C. Z. (Laville and Cossmann)
Toro and Water Cays, Panama.
Bocas del Toro, Panama.
Port Limon, coral limestones.

Genus **HALIA** Risso

Halia americana, n. sp. Plate 4, figure 7

Shell large, thin, buccinoid in form; spire elevated with shouldered whorls and deep sutures; whorls 3 plus, the earlier ones missing; the profile of the whorls is convex with a wide, shouldered, flattened or even slightly concave band just in front of the suture; the surface of the spire-whorls is smooth and unsculptured but the early ones show very faint spiral bands; the

upper half of the body-whorl is smooth but below, the whorl carries about 16, low, faint, spiral ribbons like those of *Malea* but much less strong; these spiral ribbons average about 1.25 mm in width; the growth lines cross the face of the whorl from the tip of the canal to the shoulder angle in a slightly convex curve, the convex side of which is towards the aperture; from the shoulder angle to the suture the growth lines are reversed with the concave side facing the aperture; aperture broadly elliptical; the canal was probably short and turned inward or ventrally.

Height 66, diameter 39 mm.

This truly remarkable species evidently belongs to the Pleurotomoid genus *Halia*, of which the 4 known species are European and North African in their distribution. Its type species *Halia Priamus* Meuschen is living off the coast of Spain and North West Africa. According to Cossmann, there are three Tertiary species in Europe, *H. præcedens* Pant. from the Helvetian of Italy, *H. Deshayesiana* da Costa in the Tortonian of Portugal and Italy, and *H. helicoides* Br. in the Plaisancian of the maritime Alps.

The European species are described as being entirely smooth, but the Gatun shell is sculptured on its lower half with ribbon-like spirals bands.

Gatun Stage: Mt. Hope, C. Z.

Genus **CANCELLARIA** Lamarck

Cancellaria dariena Toula Plate 6, figure 8

Cancellaria dariena Toula, 1909, Jahrb. K-K. Geol. Reichsanstalt, Wien, vol. 58, p. 31, pl. 25, fig. 13, pl. 28, fig. 2.

Cencellaria dariena Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 345, pl. 24, figs. 3, 4.

Cancellaria darienesis Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 51, pl. 4 figs. 9, 10.

var. *trachyostraca* Brown and Pilsbry.

Cancellaria dariena, var. Toula, 1909, Jahrb. der K-K, Geol. Reichsanstalt Wien, vol. 58, p. 37, pl. 28, fig. 11.

Cancellaria dariena var. *trachyostraca* Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 345, pl. 23, figs. 1, 2.

This species is most abundant in the Canal Zone. It is distinguished from the *Barretti* Guppy, which it most closely resembles by its shorter spire, larger body-whorl and a more irregular spiral sculpture. A large specimen from Mt. Hope, C. Z., has the following dimensions: Length 38, diameter 22; last whorl 30 mm. Shorter and more globose shells form the variety *trachyostraca* Brown and Pilsbry.

Gatun Stage: Gatun and Mt. Hope, C. Z.
Water and Toro Cays, Panama.
Rio Cocles, C. R.

Cancellaria Barretti Guppy — Plate 6, figure 6

Cancellaria Barretti Guppy, 1866, Quart. Jour. Geol. Soc. London, vol. 22, p. 289, pl. 17, fig. 11.

Cancellaria reticulata Gabb, 1873, Trans, Amer. Phil. Soc., vol. 15, p. 236. In part.

Cancellaria Barretti Guppy, 1876, Quart. Jour. Geol. Soc. London, vol. 32, p. 520.

Not *C. Barretti* Maury, which is *C. Mauryæ*, n. sp.

This species is the West Indian Miocene analogue or the recent *Cancellaria reticulata* Linné. The most important difference to be noted between the two shells is that in *Barretti* the columellar plicæ are more anteriorly situated and heavier. It is a Miocene fossil in the Bowden beds of Jamaica.

Gatun Stage: Banana River

Cancellaria Cossmanni, n. sp. — Plate 6, figures 9, 11

Shell of medium size, solid; nucleus of 3, small, smooth whorls; post-nuclear whorls 5, sutures deep; the whorls are slightly channeled or coronated just below the sutures; sculpture is evenly but coarsely reticulated by numerous, slightly oblique, narrow ribs, crossed by heavy, raised, narrow, spiral cords; the last whorl show 21 or 22 ribs; the spirals consists of narrow,

raised cords, separated by wide, deep interspaces; there are 4 spirals on the spire-whorls, with 15 on the last whorl and the canal; base of last whorl rounded and contracted to the short, beak-like anterior canal; columella with 2, narrow, but strong plications, of which the upper is much the strongest; aperture sub-elliptical with the outer lip carrying 8, narrow, entering liræ.

Length 25, diameter 14.5, last whorl 18 mm.

This shell should probably be considered as a variety of *C. Barretti* Guppy, but in the large series in our collection, the shell is always much smaller and with a much coarser and heaver sculpture. In some specimens, this sculpture becomes quite sharp and harsh, brought about by the crossing of the narrow spiral cords and equally narrow axial ribs.

It is an abundant and characteristic species of the Gatun beds along the Banana River, C. R.

Gatun Stage: Banana River.

Cancellaria Mauryæ, n. sp. Plate 6, figure 5

Cancellaria Barretti Maury, 1917, Bull. Amer. Pal., vol. 5, p. 226, pl. 10, fig. 1. Not of Guppy, 1866.

Shell large, ovate; an evenly conic spire in height less than the length of the aperture and a large, evenly convex last whorl; the nucleus is rather small, of 2 smooth, convex whorls followed by about 6 post-nuclear whorls; the profile of the spire-whorls is slightly convex with deep, distinct suture; the sculpture is cancellate or reticulate, the spirals and ribs of very nearly equal strength; of the axial ribs there are 40 or more on the whorl, crossed by 24 spiral cords; on the spire-whorls there are 5 spiral cords becoming 7 on the penultimate; the spirals are fairly regular, separated by interspaces 1½ times their width, in which smaller spirals may occasionally appear; faint indications of resting marks show as crowding of the ribs or as smooth, slightly humped spaces; aperture large, ovate; a thin outer lip with 17, long entering liræ; columella with 2 simple plicæ, of which the

upper is much larger; a third is probably developed on the anterior border of the canal; a well marked ridge about the base and a strong siphonal fasciole.

Height 36, diameter 23, last whorl 29, aperture 24 mm.

This shell was figured by Dr. Maury in her Dominican fossils as *C. Barretti* of Guppy, but it differs from that species in much shorter spire, more globose shell, larger aperture and by its columellar plicæ. In the species closely related to the *reticulata*, such as *Barretti*, *Cossmanni* and others, the columellar plicæ are heavy and the posterior one is usually more or less bifid. In this species, the posterior plication is large, wide and thin, especially in the interior of the shell.

The Costa Rican collection is limited to a single, imperfect specimen, so we have used as the type of this species, the original figured specimen of Dr. Maury from the Miocene of Santo Domingo.

Gatun Stage: Water Cay.

Cancellaria epistomifera Guppy

Cancellaria Moorei Gabb. 1872, Trans. Amer. Phil. Soc., vol. 15, p. 236. Not *C. Moorei* Guppy, 1866.

Cancellaria epistomifera Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 520, pl. 28, fig. 9.

Cancellaria epistomifera Cossmann, 1913, Journ. de Conchyliologie, vol. 61, p. 53, pl. 4, figs. 5, 6.

Cancellaria epistomifera Maury, 1917, Bull. Amer. Pal., vol. 5, p. 227, pl. 10, figs. 3, 4, 5.

For figures of this species, the reader is referred to Dr. Maury's Dominican Fossils. We have collected a few, small and imperfect specimens at Gatun in the Canal Zone. Small shells are easily confused with the common *C. daricna*, but in general the spire is shorter, and the spiral sculpture is heavier and more regular. At maturity, the outer lip develops below a peculiar and characteristic sulcus or pout, which is not seen on any of the associated species of *Cancellaria*.

Gatun Stage: Gatun, C. Z.

Cancellaria Rowelli Dall Plate 6, figure 7

Cancellaria Rowelli Dall, 1898, Proc. Acad. Nat. Sci. Phila., vol. 19, p. 307, pl. 29, fig. 1.

Cancellaria Rowelli Maury, 1917, Bull. Amer. Pal., vol. 5, p. 227, pl. 16, fig. 2

Two specimens of a *Cancellaria* which seem to be this species, were collected from the Gatun beds of East Grape Point Creek. The axial ribs are numerous, oblique and somewhat irregular. The spaces between the ribs are finely spiralled with deep, incised lines, producing narrow and regular spiral bands. The columellar plications are large and more or less bifid. Shell measures:

Length 30, diameter 18, last whorl 21 mm.

The Cornell Museum contains, in the Gabb collection, a single specimen which is probably this species. It agrees with the Costa Rican shells. This species was described by Dall from the Miocene of the Rio Amina, Santo Domingo.

Gatun Stage: Collection 2, East Grape Creek, C. R.

Subgenus **TRIGONOSTOMA** Blainville

Cancellaria toroensis, n. sp. Plate 6, figure 4

Cancellaria (*Trigonostoma*) aff. *Cancellaria bullata* Sowerby, Toula, 1911, Jahrb. der K-K. Geol. Reichsanstalt, vol. 61, p. 504, pl. 30, fig. 10.

Shell with 6 large, expanding whorls; the nucleus of 2½ whorls is small, closely coiled and smooth; the succeeding 2 post-nuclear whorls are small, convex and finely reticulated with 6 spirals and fine ribs; the last two whorls are deeply channeled or excavated along the suture; this excavated band is smooth, except as crossed by oblique growth lines; the last whorl is somewhat contracted above and between this contracted zone and the sutural channel is a large, heavy, more or less bifid spiral cord. This spiral cord is rendered coarsely and sharply nodulose by the axial sculpture; the sculpture consists of about 21, narrow, low, oblique riblets crossed by strong spiral cords; the spirals are

rendered slightly nodulose by the crossing of the longitudinal ribs the penultimate whorl shows 6 or 7 spirals and 14 or 15 on the last whorl; the contracted band around the upper part of the whorl is nearly free from spirals, but is bordered above as already noted by the large, bifid and strongly nodulose spiral cord; base deeply but narrowly umbilicate, spirally sculptured within; columella with 3, oblique plications; inner lip with a wide callus, finely pustulated; the outer lip is broken in the type.

Length 29, diameter 20, last whorl 23 mm.

This is the Miocene analogue of the recent West Coast *C. tuberculosa* Sowerby. It is probably the species figured by Toula from the Canal Zone and which he compared with *C. bullata* Sowerby. More recently Pilsbry and Johnson have described as *C. insularis*, a *Trigonostoma* from the Miocene of Santo Domingo and which they consider as possibly identical with Toula's Isthmian specimen. In their description they mention but 14 ribs while *toroensis* has 21 and they relate their species with the Chesapeake Miocene *perspectiva* Conrad and the Tampa *depressa* Dall, species which belong to an entirely different group.

Gatun Stage:

Toro Cays, Providence of Bocas del Toro, Panama.

Cancellaria Plummeri, n. sp. Plate 6, figures 2, 3

Shell thin and delicate, with large, loosely coiled whorls; the whorls are prominently shouldered and deeply channeled or excavated along their upper sutures; nucleus of three small, smooth whorls; post-nuclear whorls 4; the sculpture consists of very fine and delicate spiral threads or lines and three rows of slightly elevated spine-like elevations or small tubercles; the larger of these rows is found along the shoulder of the whorls bordering the excavated zone, a smaller on the middle and a small scarcely noticeable one below; on the penultimate whorl, only two rows show and on the upper spire-whorls but one; the umbilicus is deep, but narrow; the interior is concealed in the matrix.

Height 34, diameter 26, last whorl 17, aperture 19 mm.

This is a very distinctive species, characterized by its thin, delicate shell and fine sculpture. It may be compared with the recent *T. bullata* Sowerby from the Pacific coast of Central America, which differs in its larger, more expansive body-whorl and coarser sculpture. The single specimen was collected from the lower part of the Gatun formation on Toro Cays, in the eastern part of the Chiriqui Lagoon.

It is named for Mr. Fred Plummer of the Royal Dutch Oil Company of Hague, Holland.

Gatun Stage: Toro Cays.

Subgenus **APHERA** H. and A. Adams

Cancellaria islacolonis Maury Plate 6, figure 12

Cancellaria tessellata Gabb, 1873, Trans. Amer. Phil. Soc. vol. 15, p, 236. Not of Sowerby, 1832.

Cancellaria islacolonis Maury, 1917, Bull. Amer. Pal., vol. 5, p. 229. pl. 10, figs. 12, a, b.

The *C. islacolonis* was selected by Dr. Maury, as the guide fossil for the lower of her Miocene formations, the Cercado. It is a very rare fossil in Costa Rica and we have collected it only along Red Cliff Creek, in the eastern part of the Republic. There it occurs in the upper part of the Uscari and in the lower part of the Gatun.

It is closly related to the recent West Coast *C. tesselata* Sowerby.

Uscari formation; Coll. 6, Red Cliff Creek.
Gatun formation; Coll. 4, Red Cliff Creek.

(*B*) *SUPER-FAMILY RHACHIGLOSSA*

Genus **OLIVA** Bruguiere

Olives are among the most common fossils in the Miocene beds of Panama and Costa Rica. The various species, however show so few distinguishing characters, that their identification becomes at times, both difficult and uncertain. The following key has been prepared showing the characters which have been most relied upon for their separation. This key should be used in conjunction with the figures.

A. Aperture narrow and of about the same width along its whole length. Inner lip finely and regularly crenulated above.

B. Sutures deep or channelled, with the edge of the whorl projecting slightly above; spire of medium height, length 35 mm.

O. sayana var. *immortua* Pilsbry & Brown

BB. Sutures not channelled and with the upper edge of the whorl beveled or appressed.

C. Spire generally low, with concave profile and usually a projecting and globular nucleus. Length 35 mm. *O. brevispira* Gabb

CC. Spire high or short, with conic sides; nucleus or protoconch not large or prominent.

D. Spire high and conic; shell large. Length 40 mm or more

O. cylindrica Sowerby

DD. Spire short, shell usually small. Length rarely over 30 mm.

O. gatunensis Toula

AA. Aperture wide and usually expanded and flaring in front; inner lip is not crenulated above. (*Agaronia*)

B. Spire long, about 1-3 of the length of the shell;

inner lip not strongly calloused. Lenght up to 45 mm. *O. mancinella*, n. sp.

BB. Spire shorter, about 1-4 of the length of the shell; inner lip usually strongly callused. Length about 40 mm.
O testacea var. *costaricensis*, n. var.

Oliva cylindrica Sowerby Plate 7, figure 1

Oliva cylindrica Sowerby, 1849, Quart Jour. Geol. Soc. Londou, vol. 6, p. 45.

Oliva reticularis Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 288,. Not of Lamarck.

Oliva cylindrica Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 215.

Oliva cylindrica Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 526.

Oliva cylindrica Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1583.

Oliva cylindrica Cossmann, 1913, Journ. de Conchyliologie, vol. 61, p. 57, pl. 5, figs. 2, 3.

Oliva cylindrica Maury, Bull. Amer. Pal., vol. 5, p. 231, pl. 10, figs. 14, 14a.

A single, large specimen from Costa Rica, is doubtfully referred to this Dominican Miocene fossil. It differs from the more common *brevispira* by its larger size and longer, more conic spire. This shell is also closely related to the recent *O. araneosa* Lamarck of the West Coast.

Length 47, diameter 19 mm.

Gatun Stage: Upper Gatun beds, 1 mile south of shore, along Old Man Sam Creek, C. R.

Oliva brevispira Gabb Plate 7, figures 2, 3, 4

Oliva brevispira Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 215.

Oliva brevispira Maury, 1917, Bull. Amer. Pal., vol. 5 p. 232, pl. 10, figs. 16, 17.

variety *Giraudi* Cossmann

Oliva Giraudi Cossmann, 1913, Journ. de Conchyliologie, vol. 61, p. 56, pl. 5, figs. 4-8.

A fairly common species in Cost Rica. Typically the shell is short; moderatly convex, a short projecting spire and concave spire-whorls.

Unusually broad forms as illustrated by figure 4 may be separated by the name of *Giraudi* Cossmann.

A large typical shell measures:
Length 35, diameter 17 mm.

Gatun Stage: Coll.6, Red Cliff Creek, C. R.
Headwaters of Middle Creek, C. R.
Coll. 5, Grape Point Creek, C. R.

Oliva gatunensis Toula Plate 7, figure 5

Oliva gatunensis Toula, 1909, Jahrb. der K-K. Geol. Reicesanstaldt, vol. 58, p. 702, pl. 25, fig. 12.

Oliva reticularis gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 348.

Oliva gatunensis Cossmann, 1913, Jour. de Conchyliologie, vol. 61, p. 58, pl. 5, figs. 9-12.

A common species at Gatun. The largest specimen in our collection measures 28 mm. in length but Brown and Pilsbry mention shells of an length of 35-38 mm. *Oliva gatunensis*, resembles somewhat the *brevirsoira* of Gabb, but has a more even conic spire and lacks the projecting nuclear tip. The sutures are appressed. Brown and Pilsbry, place this shell as a variety of the larger, recent *Oliva reticularis* Lamarck.

Gatun Stage: Mt. Hope, C. Z.

Oliva sayana var. **immortua** Pilsbry and Brown Plate 7, figs. 6, 7

Oliva sayana var. *immortua* Pilsbry and Brown, 1917, Proc. Acad. Nat. Sci. Phila., p. 33, pl. 5, fig. 6.

The *Oliva sayana* Ravenel (*Oliva literata* of most writers)

is a common recent species along the eastern coast of United States, becoming replaced in the West Indies by the *Oliva reticularis* Lamarck. These two species are principally distinguished from each other, in that the sutures of *O. sayana* are quite deeply channelled, above which projects the upper edge of the whorls while in *reticularis* the sutures are merely deep with rounded or beveled shell margins.

O. sayana var. *immortua* was described by Pilsbry and Brown, from Gatun beds in the vicinity of Cartagena, Columbia. What appears to be the same shell is common in the exposures found along the lower part of the Banana River. Like the *brevistria* it is rather darkly colored, but no trace of a pattern is preserved. Our specimens averaged in length about 36 mm. The largest specimen measures 41 by 19.5 mm.

Gatun Stage: Banana River, C. R.

Oliva testacea Lamarck, var. **costaricensis**, n. var. Plate 7, figs. 12, 13

Shell rather solid, with a moderately projecting spire, about 1-4 or less of the total length of the shell; whorls about 5, the last, large, convex and widest about the middle; the spire-whorls appear as if mesially divided by an encircling weak callus about the lower half; aperture broadest below, with the inner lip heavily calloused above near its junction with the outer; the inner lip is non-denticulated above, along its lower part with 3 or more, irregular oblique, plaits; a broad band, arises from about the middle of the inner lip, passes obliquely downward over the back of the shell to the lower end of the outer lip.

Length 42, diameter 19 mm.

This Oliva is abundant in the Gatun beds of the Banana River, C. R. It is closely related to the recent *O. testacea* Lamarck but seems to differ in being wider, shorter and with a lower spire.

The *Oliva testacea* Lamarck (in part *O. hiatula* of some authors) is abundant along the Pacific coast of Panama, and in the Manuals, its range is given as the West Coast. Recently a close-

ly related if not identical form, was collected by us from the Pleistocene at Almirante, Panama, and several broken specimens from the beaches at Bocas del Toro, Panama, and from Manzanilla, C. R. This recent Atlantic form differs only from the typical West Coast *testacea* in being somewhat more slender and apparently differently colored.

Tryon in the Manual of Conchology unites *testacea* with *hiatula* Gmelin from West Africa.

Gatun Stage: Banana River, Coll. 5, 6, of Red Cliff Creek, C. R.

Oliva mancinella, n. sp. Plate 7, figures 8, 9

Shell slender and more delicate than the preceding; spire long and pointed and about 1-3 of the total length of the shell; 5 whorls; sutures deep; the spire-whorls have their lower half thickened by a smooth, encircling band of callus; aperture broadest about the lower half; inner lip smooth above, with only a small and weak callus at its junction with the outer lip; the outer lip carries below, 3 or 4 heavy and very oblique plaite; the outer lip is smooth and sharp.

Length 48, diameter 11 mm.

This species differs from *O. testacea* and its variety *costaricensis* by its much more slender and delicate shell. The porportions of the spire are about 1-3 of the total length of the shell.

Gatun Stage: Coll. 4, East Grape Point, Creek, C. R.

Genus **OLIVELLA** Swainson

A. Shell large, length 20 mm. or more; spire long and about ½ the total length of the shell.
Olivella goliath, n. sp.

AA. Shell smaller; spire long or short, usually less than ½ of the total length.

B. Shell short and stubby, spire rather short,

bluntly pointed; 1-3 or less the total length.
Olivella limonensis and variety *bocasensis*, n. sp. and var.

BB. Shell with a longer spire, often sharply pointed,

C. Shell rather broad, with a heavy callus about the upper part of the inner lip and extending partly over the penultimate whorl. Length 12 mm. plus.
Olivella muticoides Gabb.

CC. Shell slender, with a long, pointed spire; callus about the upper of the inner lip, slight.
Olivella Boussaci Cossmann, var.

Olivella goliath, n. sp. Plate 7, figures 22, 23

Shell large, with a long, pointed spire of about ½ of the total length of the shell; whorls about 6, with plain, nearly straight profile; sutures linear; last whorl with the greatest convexity about the middle; aperture subelliptical, broadest in front; inner lip with a thin, flat callus and with 3 small plaits below.

Length 26, diameter 10, last whorl 20, spire 13 mm
23 8.5 18 12 mm

An unusually large species, represented by two specimens from Red Cliff Creek and Banana River. Its general form is that of *O. indevisa* Guppy and *O. Boussaci* Cossmann, but nearly 4 times as large.

Gatun Stage: Banana River.
Coll. 5, Red Cliff Creek, C. R.

Olivella muticoides Gabb Plate 7, figures 11, 14, 17, 18

Oliva muticoides Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 215.
Olivella mutica variety *muticoides* Dall, 1890, Tarns. Wagner Free, Inst. Sci., vol. 3, pt. 1, p. 45.

Olivella muticoides Maury, 1917, Bull. Amer. Pal., vol. 5, p. 232, pl. 11, fig. 1.

A broad, chubby species with a spire of moderate length. A large, thick callus is formed about the upper part of the inner lip, which spreads partly over the back of the penultimate whorl, giving to it a hump-back appearance. Measurements of our Costa Rican shell run as follows:

Length 17, diameter 7, last whorl 14, spire 6.5 mm.
13 6.5 11 5.5 mm.

Gatun Stage: Coll. 5, Red Cliff Creek.
Coll. 4, East Grape Point Creek.

Olivella Boussaci Cossmann, variety Plate 7, figures 15, 16

Olivella Boussaci Cossmann, 1913, Journ. de Conchyliologie, vol. 61, p. 60, pl. 5, figs. 16-19.

The *Olivella indivisa* Guppy (Proc. U. S. Nat. Mus., vol. 19, p. 308, pl. 30, fig. 10) from Jamaica and *Olivella Boussaci* Cossmann from Martinique, belong to a closely related series characterized by their high and sharply pointed spire. The main difference seems to be that of size. The *indivisa* has a length of 6.5 mm., the *Boussaci* of 9 mm. The Costa Rican shells are generally larger and when full-grown, often 13 or more mm. in length.

Often very common.

Length 13, diameter 5, last whorl 10, spire 6.5 mm (6 whorls)

Gatun Stage: Hill 1a, Banana River.
Hill 3, Banana River.

Olivella limonensis, n. sp. Plate 7, figures 19, 20

Shell short and plump, with a small, broad, conic spire, whorls about 5, separated by deep sutures; last whorl very large, broadly cylindrical in form and slightly contracted in the middle; the inner lip has a wide callus, somewhat heavier above, with 5

fine, denticles in the middle and few, more oblique plaits below; the base is obliquely encircled by a lighter colored band; outer lip sharp, smooth within.

Length 10.5, diameter 4.75, last whorl 9, spire 2.25 mm.

This is a common shell in the coralline phase of the Gatun at Port Limon. The middle of the last whorl is usually dark colored, with the spire and the encircling basal band and callus on the inner lip white.

Gatun Stage: Port Limon.

Olivella limonensis var. **bocasensis**, n. var. Plate 7, figures 24, 25

A much smaller shell than the *limonensis* and possibly a distinct species. The spire is somewhat higher and the shell less cylindrical and pump. Dimensions as follows:

Length 6.5, diameter 2.75, last whorl 6, spire 1.5 mm.
7, 3.25, 6.5 1.75 mm.

Gatun Stage: Bocas del Toro, Panama.

Genus **ANCILLARIA** Lamarck

Ancillaria aquaensis, n. sp. Plate 7, figure 10

Shell of medium size, solid; spire elevated, composed of about 5 whorls, the sutures of which are concealed by a wide band of callus this band of callus commences on the body-whorl, a short distance below the suture, and extends to the apex; where this band covers the sutures, it forms just above, a depressed or constricted band on the middle of each whorl; the last whorl is large, with a basal band of callus, which commences near the upper end of the inner lip, descends obliquely across the back of the last whorl to the anterior tips of the outer and inner lips; a short distance above this basal band, the shell carries a single, incised line; a small umbilical pit is found just behind the middle part of the inner lip; aperture broadly sub-elliptical with a sharp outer lip.

Length 18.5, diameter 7.5, last whorl 12.5, spire 10 mm.

The *Ancillaria pinguis* Guppy, from Jamaica is probably a closely related species. Guppy's figure in the Geological Magazine, vol. 1, Decade 2, is very poor and insufficient. Our shell seems to differ by its much longer spire and more slender shell.

The *Ancillaria chipolana* Dall, figured on Plate 41, fig. 3, of the Wagner Institute, is larger and has a longer spire. No umbilical pit is shown in the figure.

Gatun Stage: Water Cay, (Isla de Aqua).

Genus **MARGINELLA** Lamarck

Marginella MacDonaldi Dall — Plate 6, figures 14, 15, 17, 19

Marginella MacDonaldi Dall, 1912, Smith, Misc. Coll., vol. 59, No. 2, p. 7.

This large *Marginella* is one of the most common and characteristic species of the Gatun beds of Costa Rica. It is extremely valiable in size and general from and heaviness of its shell, as may be seen in the accompanying figures of the more common varieties.

Typically the shell is oblong-cylindrical with a small spire of about 4 whorls, usually completely covered in front by a broad mass of callus, which spreads over the whole base of the shell and the outer lip, leaving an elevated ridge along each side as frequently seen in *Cypræa*. From the back, the spire may be seen lying in the mass of callus.

The *Marginella mindiensis* Cossmann is a smaller related species from the Canal Zone. It differs also in having its outer lip finely denticulated, while in *MacDonaldi* the outer lip is usually smooth.

Length 28, diameter of base 15, vertical diameter 10 mm.

24	14	9 mm.
25	13	9.5 mm.
17.5	11	7.5 mm.

Gatun Stage: Banana River.

Marginella mindiensis Cossmann Plate 6, figures 16, 23

Marginella mindiensis Cossmann, 1913, Journ. de Conchyliologie, vol. 61, p. 61, pl. 5, figs. 13-15.

This shell is very closely related to *M. MacDonaldi.* It differs only in being smaller and usually with the outer lip more or less denticulated. The outer lip of *M. MacDonaldi* is generally smooth but occasional specimens occur in which the outer lip is faintly denticulated. It is a species of the Canal Zone.

Length 19.5; basal diameter 11, vertical diameter 8 mm.
16 9 7 mm.

Gatun Stage: Mindi, (Cossmann)
Gatun, C. Z.

Marginella latissima Dall

Marginella latissima Dall, 1896, Prac. U. S. Nat. Mus., vol. 19, p. 308, pl. 29, fig. 11.

This is a short and very broad species, described by Dall from Moen Hill, C. R. Dall remarks: "This is perhaps the shortest and widest American species."

Length 11, diameter 8.5 mm.

Gatun Stage: Moen, Costa Rica, (Gabb).

Marginella latissima, var. **pilsbryi**, n. var. Plate 10, figures 1, 2

Marginella coniformis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 348, pl. 24, fig. 12. Not of Sowerby, 1849.

Like *M. latissima* Dall, but less broad, more pointed anteriorly, a slightly higher spire and a less heavy outer lip. In *latissima*, the two posterior plications are shown as being very oblique, while in the present form they are nearly transverse as is seen in the recent *cincta.* The outer lip is finely granulated.

Length 14, basal diameter 9.5, vertical diameter 6.75 mm.
15 11 9 mm.

This shell is figured as the *Marginella coniformis* Sowerby a common Dominican fossil, by Brown and Pilsbry. The *Marg-*

inella coniformis has been figured by Guppy in the Quarterly Journal and similiar shells were collected in abundance by the Maury expedition to Santo Domingo. It is a larger and more cylindrical form.

It is an abundant shell in the quarries west of the Gatun locks at Gatun. A single, large shell figured as figure 1 was collected from the Banana River beds.

Gatun Stage: Gatun, C. Z.
Banana River, C. R.

Marginella avena Valenciennes Plate 7, figures, 21, 28

Marginella avena Valenciennes, 1814, in Kiener, Coq. Viv. *Marginella*, p. 17, pl. 6, fig. 24.

Marginella avena Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 355.

A common, recent species along the Caribbean coast of Panama and Costa Rica. As a fossil, it occurs plentifully in the coralline phase of the Gatun at Port Limon and Bocas del Toro. The fossil shells do not differ materially from their recent representative.

The shell is elongate-cylindrical in outline, with a low, but slightly projecting spire. The aperture is norrowly linear, slightly wider in front. Outer lip thick, smooth within. The columella is provided with 4, obliquely descending plications.

A series of specimens from Limon and Bocas measure as follows.

Length 11.75,	diameter 4.25,	spire 2.
11.50	4.25	1.5.
12.50	4.50	2.

Gatun Stage: Port Limon, C. R.
Bocas del Toro, Panama.
Coll. 4, Red Cliff Greek.

Marginalla collina, n. sp. Plate 7, figures 26, 27

Shell of the general form and size of *M. avena*, but more

solid and with a lower and less differentiated spire; whorls 4 or more with sutures scarcely distinguishable under their glaze or coat of callus; aperture linear-elongate, widest in front and slightly contracted in the middle; outer lip thickened, smooth within; pillar with 4, oblique plaits of nearly equal strength.

Length 11,	diameter 4.5,	spire 1.5 mm.
10	4.25	1 mm.
11.25	5.	1 mm.

Closely related to the *Marginella avena* Val., this species differs in being more solid, less slender and with a lower spire. In *avena* the spire is clearly differentiated, with well marked sutures to its spire-whorls. In the present shell, the spire is much lower, and the sutures are more thickly covered with glaze. The thick outer lip is carried across the end of the lip and firmly joined to the spire without any preciptible line of demarcation. In *avena*, the outer lip and spire are clearly differentiated from each other.

Abundant in the Gatun beds of the Banana River.

Gatun Stage: Hill 1a, Banana River.

Marginella leander Brown and Pilsbry Plate 6, figure 22

Marginella leander Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 347, pl. 24, fig. 13.

Not known from Costa Rica, and the figure here given is from a specimen in our collection from Gatun. It is a broader and more cylindrical species than *collina*, and with a much lower and scarcely elevated spire. Our specimen measures 9 by 4 mm.

Gatun Stage: Gatun, C. R.

Marginella musacina, n. sp. Plate 10, figure 25

Shell small and slender, with a high spire of about 1-4 of the total length of the shell; whorls about 5, with sutures lightly concealed under a thin coat of glaze; last whorl narrowly cylin-

drical, widest about the upper half; aperture sublinear, with a slightly thickened lip, somewhat contracted in the middle, smooth within; inner lip smooth, or with only a thin wash of callus and with 4, very oblique plications at its extreme anterior end.

Length 9.25, diameter 3.25, spire 2.75 mm.

A small, slender species of unusual form. Two specimens were collected in Costa Rica, the type from the Banana River, the other from Old Man Sam Creek, near Manzanilla Point.

Gatun Stage: Banana River,
Along Old Man Sam Creek, one mile south of the beach, C. R.

Genus **VOLUTA** Linnæus

Voluta alfaroi Dall — Plate 8, figure 2

Voluta alfaroi 1912, Smith, Misc. Coll., vol. 59, No. 2, p. 8.

This fine species described by Dr. Dall, from the Banana River, is a common and very characteristic fossil or the Gatun beds in Costa Rica and Western Panama, but it still remains to be recorded from the Canal Zone. Allied to the recent West Indian *V. musica* Linnæus it differs most importantly in its much smaller nucleus.

The shell is heavy and in its typical form the whorls are shouldered and carry about 12 ribs, which may be quite sharp and high on the shoulder angle. The whorls are sometimes smooth, without ribs and a shoulded angle. Spiral threads usually occur on the lower one-quarter of the last whorl and on the canal, but in some cases on the spire-whorls as well. A large specimen from Water Cay measures;

Height 59 mm. diameter 34 mm.

Gatun Stage: Water Cay Panama.
Coll. 3, Red Cliff Creek; Old Man Sam Creek, 1 mile from shore; Coll. 2, Quitana Creek; Comadre Creek; Sousi creek; Coll. 5, Estrella River; Banana River; Rio Blanco; Port Limon.

Genus **SCAPHELLA** Swainson

Scaphella costaricana,n. sp. Plate 15, figure 13

Type fragmentary consisting of the nucleus and part of the three succeeding whorls; the shell is subfusiform; nucleus large, smooth and mammilate at its apex; the three following whorls are slightly contracted about the upper sutures and strongly sculptured with coarse subregular, spiral threads separated by interspaces as wide or a little more; the spiral threads and their interspaces are crossed by fine lines of growth; sutures distinct; the columella with four plaits, the posterior one being the strongest.

Length 29, diameter 18, diameter of nucleus 5.75 mm.

The unique type is unfortunately fragmentary and consists of the large, smooth, mammilate nucleus and part of the 3 succeeding whorls. The shell is subfusiform and the whole surface is strongly sculptured with coarse, spiral threads. The columella is provided with 4 strong plaits. The type specimen was found in the *Dentalium* zone of the Upper Uscari shales of Cocles Creek.

Uscari Stage: Cocles Creek.

Genus **MITRA** Lamarck

Mitra Swainsoni Broderip, var. **limonensis,** n. var. Plate 6, fig. 1.

cf. *Mitra Swainsoni* Roderip, 1835, Proc. Zool. Soc., p. 193.

cf. *Mitra Swainsoni* Reeve, Conch. Icon., *Mitra*, pl. 1, fig. 4.

cf. *Mitra Swainsoni*, var. *antillensis* Dall, 1889, Bull. Mus. Comp. Zool., vol. 18, p. 158, pl. 38, fig. 7.

Shell large, of about 6+ whorls; the spire whorls are slightly convex, the last distinctly shouldered above, depressed or slightly concave about its middle; sculpture consisting on the spire-whorls of about 6, heavy, spirals cords with sculptured interspace as seen on *Mitra Henekeni* and *longa;* on the later whorls the spiral cords become more widely spaced and on the

last are in the form of broad, subobsolete, smooth bands without the sculptured interspaces; there are about 15 spiral cords on the last whorl in addition to those of the anterior canal; anterior canal of moderate length, strongly twisted; columella with 4 plaits, heaviest above; aperture narrow.

Length 74 (apex broken), diameter 23, last whorl 52, spire 35 mm.

A single, large shell with rudely sculptured whorls was collected from the coralline limestone near Port Limon. It agrees closely with Reeve's figure of *Mitra Swainsoni*, except that the spiral bands are larger and heavier.

The *Mitra Swainsoni* is a West Coast shell belonging to the Panamic province. It is distinguished by its large size, rudely sculptured whorls and dark colored epidermis. Dall has described as the variety *antillensis*, specimens dredged off of Cape Lookout, N. C., Colombia and Yucatan.

Gatun Stage: Port Limon.

Mitra longa Gabb Plate 6, figure 10

Mitra longa Gabb, 1873. Trans. Amer. Phil. Soc., vol. 15, p. 219.

Mitra longa Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 346, pl. 24, fig. 11.

Mitra longa Maury, 1917, Bull. Amer. Pal., vol. 5, p. 238, pl. 11, figs. 11, 11a.

A long, slender species, sculptured with strong, revolving cords and fine, neatly engraved interspaces. We have collected this Dominican species only in the Canal Zone. The figured specimen has the following dimensions:

Length 40, diameter 10.5, last whorl 26, spire 21 mm.

Gatun Stage: Gatun, C. Z.

Mitra dariensis Brown ond Pilsbry Plate 6, figure 25

Mitra dariensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 60, p. 346, pl. 24, fig. 11.

A single specimen from the Island of Bocas (Columbus or Colon Island) is here figured. It differs from the *Mitra longa*, in being shorter and broader. The sculpture is less elegant.

Length 21, diameter 7, last whorl 14, spire 11 mm.

Gatun Stage: Gatun, C. Z.
Bocas del Toro, Panama.

Mitra aff. **rudis** Gabb — Plate 6, figure 13

Mitra rudis Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 220.

Shell subfusiform, biconic; whorls about 7, coarsely sculptured with strong, revolving cords, separated by interspaces of about twice their width; These interspaces are finely longitudinally sculptured with raised threads above, obsoletely so below; the spire-whorls have 5 cords, the last whorl with 11 and several smaller ones on the canal; aperture subelliptical, with a thin outer lip; columella with 4 plaits, largest above; anterior canal of medium length, strongly twisted below.

Length 33.5, diameter 12.5, last whorl 24, spire 16 mm.

It is with much uncertainty, that I have identified this rare species with Gabb's unfigured *Mitra rudis* from Santo Domingo. Gabb,s descriptions and measurements indicate a shell of much the same characters as well as dimensions.

Gatun Stage: Coll. 3, Hone Walk Creek, C. R.

Mitra poas, n. sp. — Plate 6, figures 20, 21

Shell small, nearly smooth and columbelloid in appearance; whorls 8, with straight sides; last whorl widest just above the base, which is contracted to the short anterior canal; the early spire-whorls have 5, low, smoothish spiral bands, with longitudinally sculptured, narrow interspaces; these spirals quickly become obsolete, leaving the whorls smooth except for one or two spirals bordering the upper sutures; the last whorl has about 4 spirals around the base and smaller ones on the canal; aperture subellipical, with a thin outer lip; columella with 4 plaits, larg-

est above; anterior canal of medium length and slightly bent to the left

Length 21, diameter 7.5, last whorl 13, spire 11 mm.

A smooth species of Columbelloid aspect. It is fairly abundant in the coral limestones near Port Limon.

Gatun Stage: Port Limon,

Mitra Almagrensis Toula var. **coralliophila**, n. var. Plate 6, figures 18, 24

of *Mitra Almagrensis* Toula, 1911, Jahrb. der K-K Geol. Reichsanstalt, vol. 61, p. 491, pl. 28, fig 13.

Shell small with a long spire and a shorter anterior canal; whorls about 8, with straight or slightly convex profile; sculpture of low, slightly elevated spiral cords, separated by interspaces of about their own width; these interspaces are finely sculptured by regular, raised, longitudinal threads; the spire-whorls have about 5 spiral cords, the last whorl with about 15; and smaller ones on the anterior canal; aperture subelliptical; a short canal, slightly bent to the left; pillar with 3 folds and a very small faint one below.

Length 17, diameter 6, last whorl 11, spire 10 mm.

This is a common species in the coral limestones of Limon. Toula's *Mitra Almagrensis* was described from Tehuantepec. Our shells differ from Toula's figure in being more slender and in having the body-whorl less contracted below.

Gatun Stage: Port Limon.

Genus **FUSUS** Lamarck

Fusos miocosmius, n. sp. Plate 8, figure 5

Shell long and slender, with the spire and canal of nearly equal length; whorls about 11 plus, very gradually tapering from the small nucleus to the body-whorl; whorls convex with indistinct, appressed sutures; the sculpture consists of large, swollen ribs, separated by equally wide interspaces, and the whole

crossed by strong spirals with finer threads in between; on the last whorl there are 7 ribs, which commence on the base, just above its union with the long canal, and continue across the whorl to the suture; the early spire-whorls have 6 or 7 strong spirals with 1, 2 or 3, fine threads between; on the penultimate whorl, the earlier spirals have become a primary set of 6 or 7, with their intervals occupied by a secondary set, nearly as large as the primary, and still smaller tertiary threads; the last whorl has about 18 strong spirals in addition to those on the canal; on the canal the division into primary and secondary spirals is better shown, there being about 16 primary and the same number of secondary spirals; on the extreme tip of the canal the spirals are very small and numerous; aperture small, rounded, with the outer lip internally lirated and three or more oblique plaits on the columella.

Height 100, diameter 24 mm.

This fine species is closely related to the recent *Fusus eucosmius* Dall, from the Florida coast and the West Indies. The spire of *eucosmius* is more slender, has 8 ribs instead of 7, and the outer lip is always smooth, while it is strongly lirated in *miocosmius*.

Gatun Stage: Bocas del Toro, Panama.

Fusus honensis, n. sp. Plate 8, figure 6

Shell resembling in general features the *F. miocosmius*, and with the same number of ribs; the spire is somewhat longer than the anterior canal; the whorls are somewhat more convex than those of *miocosmius* due to the more strongly knobbed ribs; the ribs are crossed on the penultimate whorl by about 6, strong, even spirals, there being no secondaries and only occasionally a small thread may appear in their intervals; the last whorl, exclusive of the canal shows 10 or 11 spirals to which are added 17 or 18 on the canal; the canal is relatively short and not perfectly straight; the aperture is probably rounded (largely broken on the type specimen) and with its outer lip internally lirated.

Height 63, diameter 20 mm.

Similiar in general form and in the number of its ribs to the *F. miocosmius* from Bocas, this species differs in its smaller, heavier shell, and in the greater coarseness of its sculpture. The spirals are heavier and primary in character throughout and the ribs are more knobbed and sharp on their crests. From the Dominican *F. Henekeni* Sowerby, it differs in being much more slender and with fewer, persistent ribs.

Gatun Stage: Coll. 4, Home Walk Creek.

Genus **FASCIOLARIA** Lamarck

Fasciolaria Gorgasiana Brown and Pilsbry — Plate 8, figure 9

Fasciolaria gorgasiana Brown and Pilsbry, 1912, Proc. Acad. Nat. Sci. Philia., vol. 64, p. 506, pl. 22, fig. 5.

This large *Fasciolaria* is fairly abundant in the Gatun beds of the Canal Zone and is recognized by its shouldered whorls and and strong knob-like ribs. The figured specimen is a large shell from the Gatun of Rio Betey, Costa Rica.

Gatun Stage: Gatun, C. Z.
Water Cay.
Rio Betey.

Fasciolaria tulipa Linnæus, variety — Plate 13, figure 4

Murex tulipa Linnæus, 1758, Syst. Nat.,ed. 10, p. 754.

Fasciolaria tulipa Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 354.

Fasciolaria tulipa Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p. 101, pl. 7 fig. 11

The Tulip shell is the common, recent *Fasciolaria*, in the Caribbean area, and it is distinguished from its more northern relative, the *distans*, by its darker coloration and sulcated sutural band. It occurs as fossil in the Pliocene of Florida.

From the coralline limestones, near Port Limon we collected three young specimens and a portion of the spire of a large individual of *Fasciolaria*. The young shells show the nucleus and

early sulcated whorls of typical *tulipa*, as fignred by Dr. Dall. They however become smooth somewhat earlier and the fragment of the spire shows the succeeding whorls to be smooth and lacking the sulcated sutural band as in *distans*.

The *Fasciolaria semistriata* Sowerby is an allied but distinct species from the Miocene of Santo Domingo, and likely to be discovered in the Gatun beds of Costa Rica and Panama. This as may be seen from the new figure of Dr. Maury, (Bull. Amer. Pal., vol. 5, p. 244, pl. 13, fig. 1), differs conspicuously from the *distans* and *tulipa*, with which it was united by Gabb, by its deep sutural depressed band, which gives to the whorls, a very convex or even shouldered appearance. The early whorls are spirally sulcated as in *tulipa*, but have in addition knob-like ribs, like those seen on *F. gorgasiana*.

Uscari Stage: Port Limon.

Fasciolaria MacDonaldi, n. sp. Plate 8, figure 1

Shell large, (type specimen imperfect, with only the last two whorls preserved); number of whorls unknown; the spire-whorls are angled about the middle, forming a board, sloping shoulder above; the last whorl has the shoulder about the upper third; the sculpture is predominantly spiral, consisting of numerous, fine, alternating threads, which are slightly roughened by the growth lines; the angle of each whorl is longitudinally undulated by 12 faint ribs; anterior canal is nearly straight with two faint plicæ; outer lip sharp.

Length (2 whorls) 70, diameter 37 mm.

Of this large and elegant species, only a single imperfect specimen with less than two complete whorls preserved, was collected from the Gatun beds of the Banana River, Costa Rica. It differs from the more common *F. Gorgasiana*, by its persistent and rough spiral sculpture and less heavily tuberculated shoulder.

This species is named in honor of Dr. D. F. MacDonald, well-known for his geologic work on the Isthmus, during the con-

struction of the Panana Canal, and former Chief Geologist of the geological force of the Sinclair Oil Corporation in Panana and Costa Rica.

Gatun Stage: Hill No. 2, Banana River.

Genus **LATIRUS** Montfort

Latirus infundibulum Gmelin, variety — Plate 8, figure 10

Latirus infundibulum Gmelin, Lamarck, Anim. sans, Vert. (ed, Desh.) vol. 9, p. 386.

Latirus infundibulum Guppy, 1866, Quart. Journ. Geol. Soc. Loudon, vol. 22, p. 288.

Latirus infundibulum Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 217.

Latirus infundibulum Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 354.

Latirus infundibulum Maury, 1917, Bull. Amer. Pal., vol. 5, p. 246, pl. 13, fig. 3

A common recent species of the West Indian and Costa Rican coasts. Only an imperfent specimen was collected from the Gatun beds of lower Pumbri Creek, a small tributary of the Estrella River. From recent examples of *infundibulum*, it differs by its shorter canal, more numerous ribs (9 instead 6 or 7), and heavier spiral sculpture. The specimen is, however, to fragmentary to serve as a type for a new variety or related species.

Gatun Siage; Coll. 7, Pumbri Creek, C. R.

Latirus irazu, n. sp. — Plate 8, figure 12

Shell subfusiform; solid, with a long spire and shorter canal; whorls about 9, with heavy, sharp, knob-like ribs and finer spiral threads; the last whorl shows 7, sharp, pointed ribs, which are continuous from suture to suture, but only feebly across the base of the last whorl; the suture is bordered anteriorly by a prominent, frilled band or cord, formed by the elevated edges

of the growth lines: spirals consisting of low, raised threads with wide interspaces; canal short, straight above but bent below, and with three small, smooth folds on the columella above; aperture with a thin outer lip.

Length 46, diameter 17, last whorl 29, spire 24 mm.

A smaller and more delicate species than the preceding *L. infundibulum* Gmelin. In the present shell, the ribs are sharper and more pointed, and the canal is shorter and more strongly reflected backwards. The strongly frilled sutural band is lacking or only imperfectly developed on *infundibulum*.

Gatun Stage: Port Limon.

Latirus taurus, n. sp. Plate 8, figure 4

Shell large, slender, solid with the spire more than ½ the height of the shell; whorls convex, with indistinct sutures; sculpture of very regular, narrow ribs with deep interspaces, and crossed by strong, ridge-like spiral cords; whorls about 9; axial sculpture on last whorl with about 11 ribs; the ribs commence well down on the base and continue to the upper suture and are nearly in line across the spire-whorls to the apex; the spirals consist of ridge-like cords and finer spiral threads; there are 2 principal spirals on the spire-whorls which cross the middle of the whorls; there are 4 principal spirals on the last whorl above the edge of the base, below which there are a few smaller threads; the anterior canal has 2 strong cords and finer threads are scattered over the whole shell; the anterior canal is straight and stocky and carries at its base a deep but narrow umbilical pit; the columella has 4 small folds; aperture subovate, anteriorly extended to form the long narrow canal; outer lip smooth within.

Height 60, diameter 25, aperture 32 mm.

A large, solid and strongly sculptured shell. The straight, narrow ribs are spaced regularly over the whorls of the shell and are continuous from the base to the upper suture. They are

crossed by heavy, ridge-like, spiral cords, which on crossing the deep interspaces between the ribs, form small, sunken pits, so that the sculpture appears coarsely trellised.

Gatun Stage: Toro Cays.

Genus **PTYCHOSALPINX** Gill

Ptychosalpinx? dentalis, n. sp. Plate 15, figures 14, 18

Shell buccinoid with convex, cancellated whorls; whorls about 6, with channelled sutures so that the whorls appear narrowly shouldered above; the sculpture is predominantly spiralled, the penultimate whorl with 7 strong spiral cords with interspaces 2 or 3 times their width; small spiral threads may appear in the interspaces; the last whorl has 14 or more spirals and the wide interspaces with one or more finer threads; the spirals are crossed by coarse wavy lines of growth, producing a sub-cancellate sculpture; the aperture is subovate; a well-developed siphonal sinus; the columella carries a single sharp plication at its lower end; the outer lip is slightly thickened and bears within about 12, small, narrow liræ.

Height 28, diameter 11, aperture 16 mm.

The generic relation of this interesting species is very much in doubt. It has the general form of *Cominella*, but its columella is provided with a strong anterior plication. In this regard it agrees with *Ptychosalpinx* of which there are several species in the Chesapeake Miocene. The apex of *dentalis*, appears to have been pointed and sharp, although all of our specimens have the tip of the spire very much weathered. True *Ptychosalpinx* is characterized by a large, convex and blunt nucleus and the outer lip is thin and smooth within. The outer lip of *dentalis* is slightly thickened and internally finely lirated.

The *P? dentalis*, is a very characteristic fossil of the *Dentalium* zone of the Upper Uscari formation.

Uscari formation. *Coco Plum, Panama.*
Rio Coclés.
Comadre Creek, etc.

Genus PERISTERNIA Morch

Peristernia insula, n. sp. Plate 8, figure 11

Shell small, with a sharp pointed spire, a little longer than the aperture; the general form and sculpture of the shell is like that of *Urosalpinx cinereus* Say; nucleus of 2 small smooth whorls, followed by 7 post-nuclear; the profile of the spire-whorls is convex and strongly sculptured with ribs and sharp spiral cords; the last whorl has 8 ribs which are nearly lacking from the base of the whorl; the spiral sculpture consists of 2 principal cords about the middle of the earlier whorls above which lie smaller threads about the suture; on the later whorls, the spirals are somewhat heavier about the middle but irregular with finer, intermediate threads in between the principal ones; base contracted; aperture subcircular; outer and inner lips crenulated or denticulated; canal short and bent.

Height 23, diameter 13, aperture 11 mm.

This and the following *tortugera* seem correctly referable to the genus *Peristernia* Morch. The *P. insula* is somewhat like young specimens of *filicata* Conrad, from the Chesapeake Miocene of eastern United States, but has a longer and more pointed spire, and heavier sculpture.

Gatun Stage: Water Cay.

Peristernia tortugera, n. sp. Plate 8, figure 13

Shell elevated with a spire much longer than the aperture; nucleus of about 2½ small, smooth whorls; the post-nuclear whorls about 7; sutures distinct; whorls strongly convex, shouldered; sculpture of narrow, heavy ribs, widely spaced and numbering on the last whorl about 9; the rib are continued across the whorls from suture to suture and for a short distance down on

the base; the spirals consists of irregular sharp cords; the early spire whorls carry 2 main spiral cords but bordered above and below by finer threads; the 2 principal spirals are continued on the later whorls but are nearly equalled in strength by the other spirals and hence lose their prominence; a short anterior canal; base strongly contracted.

Height 29, diameter 14.5, aperture 12 mm.

Distinguished from the preceding *insula* by its very much longer spire, more strongly contracted base and different spiral sculpture.

Gatun Stage: Port Limon.

Genus **XANCUS** Bolton

Xancus scopulus, n. sp. Plate 11, figure 1

Shell large, solid and heavy; spire nearly as long as the aperture; spire-whorls 6 plus (the tip broken), strongly coronate above and with large, wide, persistant ribs; the earlier spire-whorls are simply shouldered or angled about the middle, but the area about the upper sutures rapidly deepens and on the later whorls is a deep, excavated sutural zone, above which project the ends of the ribs; there is a strong sutural cord and a rather wide, ribbon-like band just above, forming at first a strongly appressed suture; the last whorl has about 7 large, wide ribs, the areas between appearing as troughs or depressions; the sutural excavated zone carries several irregular spiral threads which are crossed by large growth-lines so that the resulting sculpture is more or less cancellate, more particularily on the earlier whorls; the growth-lines cross the sutural cord and upon the ribbon above, become much crowded and strongly bent forwards; the young shell was sculptured over the whole shell with strong spirals, but with maturity, the spirals become obsolete and the shell is smooth and polished; columella with 3, strong plicæ as in the recent *scolymus*; a long anterior canal, with a narrow, deep umbilicus behind the spreading inner lip.

Height 265, diameter 136, aperture 158, last whorl 195 mm.

This very remarkable species is an extreme development of the *X. scolymus* stock in which the upper portion of the whorl becomes a wide, deep, excavated sutural zone. Above this excavated zone, project the high, rounded or appressed ribs and the carinate edge of the whorls. *X. scolymus* Gmelin, a recent specie found plentifully along the north Panama coast, has the whorls simply shouldered, often merely rounded.

The Santo Domingan Miocene contains *X. validus* Sowerby, which has been identified by some with *scolymus*. In *validus*, the ribs are more numerous (about 10) and are sharper and more tubercular in form.

Gatun Stage: Banana River.

Genus **MELONGENA** Schumacher

Melongena consors Sowerby Plate 9, figure 1

Pyrula consors Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 49.

Melongena melongena Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 205. Not of Linnæus.

Pyrula melongena Guppy, 1874, Geol. Mag., vol. 11, p. 438.

Pyrula melongena Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 523.

Melongena consors Dall, 1900, Trans, Wagner Free Inst. Sci., vol. 3, pt 1, p. 121.

Melongena consors Maury, Bull. Amer. Pal., vol. 5, p. 249, pl. 14, fig. 5.

The *Melongena consors* is not a common fossil in Costa Rica. It is closely related to the recent *M. corona* Gmelin of the West Indies, the fossils shells differing mostly in having a longer spire and somewhat different sculpture above.

The Costa Rican examples are exactly like Miocene specimens from Santo Doingo. As a fossil it occurs in the Miocene of Jamaica, Santo Domingo and Venezuela.

Gatun Stage: Coll. 5, Old Man Sam Creek.
Codes Creek.

Genus **SOLENOSTEIRA** Dall

Solenosteira Dalli, Brown and Pilsbry Plate 8, figure 8

Solenosteira dalli, Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 348, pl. 24, fig. 14.

Coralliophila gatunensis Toula, 1911, Jahrb. der K-K Geol. Reichsanstalt, vol. 61, p. 502, pl. 30, fig. 9.

A common species in the Canal Zone and figured here for comparision with the following species. The whorls are strongly shouldered, a feature accentuated by the few, but high, angled ribs. The spirals are heavy, raised cords, over and between which are finer secondary and tertiary threads.

Length 34, diameter 23, last whorl 27, spire 15 mm.

Gatun Stage: Gatun, Mt. Hope, C. Z.

Solenosteira Vaughani Dall, var. **medioamericana,** n. var. Plate 8, fig. 7

cf. *Solenosteira Vaughani* Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1633, pl. 60, fig. 18.

Shell solid, with a small pointed nucleus of 2 smooth whorls, and 6 post-nuclear; spire conic, of about ½ the total length of the shell; whorls convex, or bluntly shouldered about the middle ; sculpture of numerous low ribs which are rounded, and heaviest on the shoulder angles; There are 7 to 10 ribs on the last whorl; spirals of raised cords, with finer threads on the interspaces; the spire-whorls have about 6 primary spirals, the last whorl with 18, including those of the short canal; canal short with a deep but narrow umbilical pit; aperture oval, a thick inner and outer lip, the outer with about 10, long, entering liræ and the inner with three small denticles above.

Length 42, diameter 24, last whorl 34, spire 17 mm.
34 21.5 28 13 mm.

The *Solenosteira Vaughani* is a Chesapeake Miocene species

from Jackson Bluff and Coe's Mill, Florida. Dall's figure in the Wagner Free Institute, is so like our shell from western Panama and Costa Rica, that there can be but little doubt of their close affinities.

The present shell is larger than the *S. Dalli*, of the Canal Zone, with more numerous, obtuse and not sharp ribs, and with a wider and deeper umbilical pit. A canal is developed at the posterior angle of the aperture as in the recent *S. pallida* Brod. while in *S. Dalli*, the posterior portion of the aperture is rounded and there is no canal.

Gatun Stage: Toro and Water Cay, Panama.
Hill 1a, Banana River, C. R.

Solenosteira chiriquiensis, n. sp. Plate 8, figure 3

Shell large, heavy; spire about ½ the height of the shell; whorls about 7, strongly angled about the middle and carrying heavy knob-like ribs, crossed by heavy spiral cords; the last whorl has 8 ribs which are developed only on the middle of the shell, being lacking from the upper slope and from the base of the last whorl; the tops of the ribs are crossed by 2 strong, spiral cords with a wide, trough-like interval between; above the 2 principal spiral cords, there are 4 smaller cords on the upper slope and on the base and canal 10 or 11; base of the last whorl contracted to form the straight canal which carries a deep, narrow umbilius; aperture subelliptical.

Height 57, diameter 34, aperture 34 mm.

It is possible that this species belong to the genus *Cymia* rather than *Solenosteira*, but its aperture is so completely filled with a hard sandstone matrix that the presence or absence of a columellar fold cannot be determined. Its sculpture however is more like *Solenosteira* than *Cymia*. The species will be recognized by its large size and characteristic sculpture.

Gatun Stage: Water Cay.

Genus **METULA** H. and A. Adams

Metula cancellata Gabb Plate 10, figure 12

Metula cancellata Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 205.

Metula cancellata Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 351.

Metula cancellata Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1584.

Metula cancellata Maury, 1917, Bull. Amer. Pal., vol. 5, 249, pl. 14, fig. 19.

Less common in Costa Rica and Panama than the following species and from which it is easily distinguished by its usual smaller size, more delicate shell, and fine sculpture.

The spiral threads on the last whorl number about 37 and are crossed by nearly as fine longitudinal ribs. The resulting reticulate sculpture is fine and neat. Our largest shell, a specimen from Bocas with 6 whorls measures:

Length 19, diameter 6.5, last whorl 14, spire 9, aperture 10 mm.

Gatun Stage: Bocas del Toro, Panama.
Hill 1a, Banana River, C. R.

Metula Gabbi Brown and Pilsbry Plate 10, figure 11

Metula Gabbi Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 351, pl. 25, figs. 4, 8.

This beautiful species is fairly common in the Canal Zone, but usually in a fragmentary condition. It related to the *Metula cancellata* Gabb, differing mainly in its larger size and heavier sculpture. On a speciman of 8 whorls from Gatun, the spirals on the spire whorl number about 8 and 39 on the last whorl and anterior canal. The 2 upper spirals are noticeably stronger than the others. Aperture long and narrow and finely denticulated along the interior of the outer lip.

The figured specimen from Gatun has the following measurements:

Length 29, diameter 10.5, last whorl 22, spire 12.5, aperture 16 mm.

Gatun Stage: Gatun and Mt. Hope, C. Z.

Metula Harrisi, n. sp. Plate 10, figure 10

Shell solid and more coarsely sculptured then *Metula Gabbi*, and with a longer and broaded spire and shorter aperture; whorl 6 plus, (apex lost); sculpture of spiral cords and finer, curved longitudinal ribs; the spire whorls with 8 spiral cords which are finest next to the lower suture, become progressively stronger above; on the last whorl and canal there are about 25 spirals; the spirals are slightly nodulated by the ribs of which there are about 40 on the last whorl; certain of the spirals on the middle of the whorl are double; aperture ovate-elliptical with a strongly thickened outer lip, internally with about 19 short liræ; inner lip smooth; canal short and twisted.

Length 26.5, diameter 11, last whorl 19.5, aperture 13.5, spire 14 mm.

A solid and more coarsely sculptured species than the *Metula Gabbi*. The spire is broad and porportionately longer, due to the shorter aperture. In *Gabbi* the spirals are of nearly equal strength over most of the shell surface with exception of those immediately bordering the upper suture. In the present species the spirals are finer below and progressively become stronger posteriorly.

The type specimen was collected in the lower Gatun sandstones of Coco Plum, Panana.

Gatun Stage: Coco Plum, Bocas del Toro, Panama.

Metula Harrisi var. **limonensis**, n. sp. Plate 10, figures 5, 6

Shell more slender; a narrow and longer aperture more nearly the length of the spire; sculpture coarsely reticulate,

with 10 spirals on the penultimate whorl, about 26 on the last; aperture long, with a thickened outer lip, internally lirated in unison with the external spiral cords; inner lip smooth with a long, bent, beak-like canal.

Length 27, diameter 9.50, last whorl 19, aperture 14, spire 13 mm.

Several specimens from the coral limestones of Port Limon. They are most closely related to *Harrisi*, in their heavy shell, coarse sculpture, and thickened outer lip. They differ in being more slender, a longer aperture and in minor details of their sculpture.

Gatun Stage: Port Limon,

Genus PHOS Montford

Phos gatunensis Toula — Plate 9, figures 4, 5

Phos gatunensis Toula, 1909, Jahrb. der K-K Geol. Reichsanstalt, Wein vol. 38, p. 701, pl. 28, fig 6; pl. 25, fig. 11.

Phos gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila. vol. 63, p. 349, pl. 25, figs. 1, 2.

The *Phos gatunensis* is possibly the most common fossil in the Gatun beds of the Canal Zone and the adjacent sedimentary areas in the Province of Colon, but it still remains to be collected outside of this, its type area.

The shell is typically rather slender, with a sub-reticulate sculpture formed by the intersection of its numerous, straight longitudinal ribs, and the nearly equal, regular, strap-like, spiral cords.

A typical specimen measures as follows:

Length 30, diameter 13, last whorl 20, spire 15 mm.

Gatun Stage: Gatun, C. Z.

Phos mexicanus Bose — Plate 9, figures 10, 11

Phos mexicanus Bose, 1906, Bol. de Inst. Geol. de Mexican, numero 22, p. 38, pl. 4, figs. 18-21.

Shell more broad and solid than *gatunensis* of the Canal Zone; whorls about 8, those of the spire with nearly straight or only slightly convex sides; last whorl large, broad, convex and widest about the middle; the sculpture is much more coarsely reticulate than in *gatunensis*, with the intersection points of the ribs and spirals more or less subnodulose; the last whorl has about 18 ribs, which on the back of the outer lip are more closely spaced than elsewhere; the spiral cords are not so heavy as the ribs, separated by wider interspaces which carry one or sometimes two very, fine, spiral threads; in addition, the spiral interspaces are very finely and neatly sculptured with fine, raised, longitudinal lines, corresponding to the growth-lines; on the spire-whorls there are 5 spiral cords, 13 on the last whorl and 3 more on the canal; canal short, twisted; aperture sub-elliptical, with a moderately heavy, but not thickened outer lip and internally lirated.

Length 30, diameter 15.5, last whorl 21, spire 14.5 mm.

A broader, more solid and more coarsely sculptured shell than the *Phos gatunensis* of the Canal Zone,

It was described from the Miocene of Paso Real, near Tuxtepec, in the State of Oaxaca, Mexico, by Dr. Bose, whose excellent figures agree exactly with specimens from Water Cay. The several species of *Phos*, are often extremely abundant but local in their distribution. Such is the case of *Phos gatunensis* of the Canal Zone, the *Phos Moorei* var. *costaricensis* of the Banana River. Likewise in the present instance; the *mexicanus*, is a very abundant fossil of the Gatun beds of the islands of the Chiriqui Lagoon and the adjacent Valiente Peninsula. A few specimens have also been collected in Costa Rica.

Gatun Stage: Water Cay. Toro Cay. Coco Plum, etc. Rio Cocles, C. R.

Phos Moorei Guppy, var. **costaricensis**, n. var. Plate 9, figures 8, 9

Shell of medium size, solid; spire long about one-half the total length of the shell; whorls 10, of which the first two belong

to a small smooth nucleus; succeeding whorls are sculptured with heavy persistent, straight ribs (13 or 14) on the last whorl; the ribs are crossed by even, raised, spiral cords; the spire-whorls have 4 spiral cords and a small one close to the upper suture; anterior canal short and strongly twisted; aperture subelliptical, the outer lip with about 10, strong and regular internal liræ.

Height 27, diameter 12, last whorl 17, spire 14 mm.

This is the common *Phos* of the Banana River. Although closely related to *Moorei*, from Jamaica, the Costa Rican fossils are smaller and more slender, as compared with Guppy's figure in the Quarterly Journal, vol. 22, pl. 16, fig. 11.

Dr. Maury's *Phos Moorei*, from the Miocene of Santo Domingo probably represents a distinct species, differing by its more slender spire, and in sculpture. The spiral intervals of *costaricensis* are smooth, while in the Santo Domingan shells, they carry fine spiral threads, which are best seen on the spire-whorls, sometimes becoming obsolete on the later.

Gatun Stage: Banana River,
Old Man Sam Creek, 1 mile from shore or beach.

Phos elegans Gupp, var. **limonensis**, n. var. Plate 9, figures 12, 13

Shell usually smaller, more slender and delicate than the preceding species; the spire is long, composed of about 9 whorls: the nucleus consists of 4 whorls, the first 2 are small, smooth and convex, the last 2, smooth, but sharply keeled about the periphery on the last 1-4 of the last nuclear whorl, faint curved lines appear above the peripheral keel, they gradually increase in strength and on the 1st post-nuclear whorl become the longitudinal ribs; the sculpture consists of fine, longitudinal ribs (23 or 24 on the last whorl); occasionally a rib may become greatly enlarged, forming varix-like thickenings corresponding to resting stages; the ribs are overrun by primary, secondary and tertiary spiral threads; the later spire whorls have about 6 spirals,

with about 17 on the last whorl and the canal; aperture suboval, with a heavy but not thickened outer lip, internally lirated.

Length 27, diameter 11, last whorl 17, spire 4.5 mm.

This shell is related to the *Phos elegans* Guppy of the Miocene of Jamaica and Santo Domingo. Our shells differ from typical examples of *elegans* from Santo Domingo, in being larger, and more coarsely sculptured.

Varix-like thickenings occur scattered along the spire-whorls. The protoconch of typical *elegans* and *limonensis* are practically identical. The recent West Coast *Phos Veraquensis* Hinds is a related but more finely sculptured species.

Gatun Stage: Port Limon.
Bocas del Toro.

Phos estrellensis, n. sp. Plate 9, figures 17, 18

Shell small, slender, solid; spire much longer than the aperture, pointed; whorls of the spire 6 or more, convex in profile with deep sutures; sculpture of narrow, straight ribs which commence on the columellar area and pass across the whorl to the upper suture; there are 12 or 13 ribs on the last whorl which are evenly and widely spaced except on the back of the outer lip where they are smaller and more numerous; the spirals consist of a primary set of threads or cords with a single, smaller secondary thread in each interspace except on the base and the canal; the primary threads crossing the ribs form small, whitish tubercles; the spire-whorls have 4 primary spirals and there are 11 on the last whorl, exclusively of the canal; aperture sub elliptical, produced anteriorly to form the straight anterior canal; outer lip thickened and internally lirated.

Height 20, diameter 8, aperture 9 mm.

A small, slender species, coarsely sculptured like the larger and broader *Phos Moorei* variety *costaricensis*. It is limited in our collections to the Gatun beds of the Estrella River.

Gatnu Stage: Coll. 6, 7, Estrella River.

Phos subsemicostatus Brown and Pilsbry Plate 9, figure 15

Phos subsemicostatus Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 350, pl. 25, fig. 3.

A larger and finer sculptured species than the Dominican *Phos semicostatus* of Gabb. A single imperfect specimen was collected from Zone E of Saury Creek.

Gatun Stage: Gatun (Brown and Pilsbry)
Zone E, Saury Creek, C. R.

Phos Veatchi, n. sp. Plate 9, figures 2, 3

Shell large and heavy, with a moderately long, coarse spire of about 9 whorls; nucleus small, of 2 smooth whorls; whorls of the spire moderately convex, with strong ribs continuous from suture to suture; sutures appressed and bordered below by a small spiral; the last whorl is widest about the middle and contracted below to the short anterior canal; sculpture of heavy, persistent ribs and regular raised spirals; the last whorl has 8 ribs; the spirals consists of raised threads, separated by wide, interspaces; an occasional secondary spiral will appear in the interspace but they are generally smooth or only obsoletely sculptured by the growth lines; there are 8 spirals on the spire-whorls, 16 or 17 on the last whorl; aperture ovate, with the outer lip thickened by the last rib, and internally with 9, long, entering liræ; inner lip formed by a raised, spreading callus, armed above by a tooth-like denticle and a strong fold below on the edge of the canal.

Length 43, diameter 22, last whorl 28, spire 25 mm.

A large, robust species from Hill 1a of the Banana River. It differs from the *subsemicostata* by its strong persistent ribs and coarser spirals.

It is named for Dr. A. C. Veatch, Director of the Exploration work of the Sinclair Oil Corporation, under whose direction the Costa Rican collections were made.

Gatun Stage: Hill 1a Banana River.

Phos beteyensis, n. sp. Plate 9, figure 6

Shell of the type of *subsemicostata*; whorls 3, moderately convex; sculpture with the axial element very weak but present on the penultimate whorl as fine, sub-obsolete, narrow ribs or irregular wrinkles on the shell surface; they are absent from the last whorl; the spiral sculpture consists of a broad zone, about the upper 1-3 of the spire whorl on which are irregularly distributed about 5 raised spiral threads; below this zone, the sculpture is largely in the form of broad uneven bands formed between incised spiral lines; on the last last whorl, this later zone occuppies the middle of the whorl; the zone of raised spirals above the more smooth area of banded spirals gives to the whorls a slightly coronated appearance.

Length 27 (2½ whorls), diameter 15, last whorl 21 mm.

The type specimen is very incomplete, but its characters are so distinctive and unlike any other species of *Phos* which we have seen that its discription is advisable. Like the *subsemicostatus* the longitudinal ribs or costæ fade out on the later whorls.

Gatun Stage; Betey Creek, C. R.

Phos metuloides Dall Plate 9, figure 16

Phos metuloides Dall, 1896, Proc. U. S. Nat. Mus., vol. 19, p. 310, pl. 28, fig. 15.

Phos metuloides Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 350.

Phos metuloides Maury, 1917, Bull. Amer. Pal., vol. 5, p. 252, pl. 14, fig. 17.

A small species with a neat sculpture recalling that of *Metula cancellata* and *gabbi*. It is not rare in the Gatun beds of Mt. Hope in the Canal Zone. Dall also records it from the Miocene of Santo Domingo.

Length 19, diameter 9, spire whorl 13.5, spire 10 mm.

Gatun Stage: Mt. Hope.

Genus **ALECTRION** Montfort

Alectrion ranuncula, n. sp. Plate 9, figures 20, 22

Shell of medium size, with a large body-whorl and a sharp pointed spire; the general form and sculpture recalls the recent *A. acuta* Say; spire about the same length as the aperture and canal and composed of about 7 whorls, of which the first 2 belong to the small, smooth nucleus; the profile of the spire-whorls is convex with deep, excavated sutures; sculpture of narrow ribs, the tops of which are crossed by spirals and separated by wide, smooth interspaces; the last whorl has about 9 ribs which are large and humped on the ventral face, finer and more numerous on the back; there are 3 spirals on the spire-whorls and 7 on the last with several more on the short canal; aperture subcircular with a large, heavy outer lip, internally denticulated.

The general form and sculpturing recalls the recent East Coast *Alectrion acuta* Say, but the Costa Rican shell is much broader as indicated by the following comparative measurements with *A. acuta* Say, of the same height.

Height 14.00, diameter 6.25, last whorl 8, aperture 6 mm.
(*Alectrion acuta* Say)

Height 14.50, diameter 8.25, last whorl 9, aperture 7.5 mm.
(*Alectrion ranuncula*, n. sp.)

It is not uncommon in the Gatun beds of the Banana River.

Gatun Stage: Hill 1a, Banana River.
Coll. 7 Estrella.

Alectrion losquemadica Maury Plate 9, figure 21

Alectrion losquemadica Maury, 1917, Bull. Amer. Pal., vol. 5, p. 255, pl. 15, figs. 22, 23.

The Costa Rica fossil is similiar in its sculpturing and form to the common recent West Indian *A. ambigua* Montfort. As Maury has pointed out in regard to the Dominican examples, the

difference between *losquemadica* and *ambigua*, lies in the protoconch, which in typical *ambigua* is short and blunt, but pointed and composed of several whorls in *losquemadica*. Our shells are larger than typical *losquemadica* from Santo Domingo.

Height 11.50, diameter 7.00 mm.

Gatun Stage: Port Limon.
Coll. 7, Estrella River.

Alectrion merenda, n. sp. Plate 9, figure 19

Shell small, a large body whorl and a sharp pointed spire; nucleus of 2 small, convex whorls followed by 5 post-nuclear whorls; sutures distinct but not excavated; the sculpture consists of about 12 ribs which are variable in their strength and spacing; the ribs are crossed by subequal spiral cords separated by wide, interspaces in which there may appear a smaller intermediate spiral; the suture is bordered by a set of 2 or 3 finer spirals; there are 3 spirals on the spire-whorls and 8 on the last whorl above the contracted zone of the canal; aperture subcircular with a thick, heavy outer lip.

Height 7, diameter 4.5 mm.

The aperture is completely filled with a hard matrix which completely conceals the characters of the inner and outer lips.

Uscari Stage: Old Man Sam Creek.

Genus **NORTHIA** Gray

Northia northiae Gray, var. **miocenica**, n. var. Plate 9, figures 7, 14

cf. *Northia northiæ* Gray, 1834, in Griffith's Cuvier, pl. 30, fig. 2.
cf. *Northia northiæ* Kiener, 1832 Icon., *Buccinum*, p. 23, pl. 9, fig. 28.

The *Northia northiæ* Gray, (*N. serrata* Dufresne) is a common and characteristic West Coast or Pacific species, ranging from the Bay of Panana to Guayaquil Ecuador. The fossils represented by three incomplete specimens differ only from recent examples from Panama in lacking the hump-like thickening in

back of the outer lip and the corresponding shoulder to its whorls. But this is not an importnnt character and recent examples may sometimes lack this character.

But few investigators who have studied the West Iadian Miocene have failed to note the large percentage of species, closely related or even identical with recent Pacific species, a condition indicative of the union of the Atlantic and Pacific, permitting a free intermingling of their respective faunas. Late during the Miocene, this union was brought to a close or largely restricted, and since then the Pacific element has gradually given way before the encroachment and development of the West Indian. That this extinction has been a gradual one is shown by the Pleistocene deposits of Panama containg several common West Coast species not known from the recent Caribbean. Such species are the *Pecten ventricosus* Sowerby and *Northia northiæ* both recorded by Dall from the Pleistocene of Panama or Costa Rica.

Gatun Stage: Middle Creek.
Banana River, Hill No. 3.
Coll. 6, Red Cliff Creek.

Genus **COLUMBELLA** Lamarck

Columbella submercatoria, n. sp. Plate 10, figures 33, 34

Shell ovate, solid, a small conic spire and a large body-whorl; whorls about 7; spire-whorls but slightly convex so that the profile of the spire is nearly plane; last whorl large, broadly convex about the upper 1-3 and sloping evenly below to the short, produced anterior canal; sculpture of subobsolete spirals, there being about 6 on the spire-whorls and about 22 on the last whorl; aperture linear with a thickened outer lip, expanded in the middle and finely and evenly crenulated throughout; anterior canal short and armed with 8 strong denticles.

Length 17, diameter 10.5, aperture 11, spire 5.5 mm.

Closely related to the recent *C. mercatoria* Linn., common along the northern Costa Rican coast, but differs in its more

globose form and finer spiral sculpturing. Traces of coloration are still preserved as faint blotches of yellow scattered over the back of the shell.

Typical *Columbella* has heretofore not been recorded from beds older then the Pliocene either in America or Europe.

Gatun Stage: Zone 5, Red Cliff Creek.

Genus **STROMBINA** Moerch

Strombina ambigua Guppy Plate 10, figure 9

Columbella ambigua Guppy, 1866, Quart. Jour.Geol. Soc. London, vol. 22, p. 288, pl. 16, fig 8.

Strombina ambigua Dall, 1903, Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, p. 1584.

This species was described from the Bowden beds of Jamaica, of Miocene age. Our shells from Costa Rica agree exactly with Guppy's figure in the Quarterly Journal.

A large species of Columbelloid aspect due in large measure to the slight thickening of its outer lip. The sculpture consists of about 25 ribs, which are smooth on the spire whorls and upper half of the last. The base of the last whorl and the canal have in addition about 14 spiral cords.

Length 27 (7 plus whorls), diameter 10, spire 15, aperture 13 mm.

Gatun Stage: Banana River.

Strombina Lessepiana Brown and Pilsbry Plate 10, figures 13, 20

Strombina lessepiana Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 352, pl. 25, figs. 11, 12.

Columbella (*Strombina*) *gatunensis* Toula, 1911, Jahrb. der K-K, Geol. Reichsanstalt, Wien, vol. 61, p. 501, pl. 30, fig. 8.

An abundant species in the Canal Zone and with the exception of *S. ambigua*, the largest species of *Strombina* in the Miocene beds of Panama and Costa Rica. The spire is long and smooth, with the exception that the upper sutural zone is usual-

ly distantly raised into small, longitudinal plicæ which is most characteristic. An average specimen from the Canal Zone will measure:

Length 25, diameter 10, spire 13, aperture 12.50 mm.

We collected from the lower Gatun sandstones of Cocles Creek, near Old Harbor, Costa Rica, several small Strombinas which except for size are typical *Lessepiana*.

Gatun Stage: Gatun and Mt. Hope, C. Z.
Cocles Creek, C. R.

Strombina matima, n. sp. Plate 10, figure 7

Shell ovate, moderately solid with a long evenly tapering and sharp-pointed spire; nucleus small, pointed and of three, smooth whorls; post-nuclear whorls 6; suture distinct and bordered anteriorly by a small sutural ridge; the sculpture consists of about 18, smooth, narrow ribs, which are lacking from the back of the last whorl, which is smooth; the ribs are oblique in direction and along the upper sutures are slightly knobbed by the sutural ridge; the base of the last whorl and canal carries about 12 spirals; aperture subelliptical with a heavy outer lip internally provided with 3 or 4 denticles about the middle; anterior canal straight and smooth within.

Height 12, diameter 5.25, aperture 6 mm.

This is a species with a long, evenly-tapering spire and small nucleus. The spire-whorls are sculptured with numerous, small, smooth riblets. The riblets are obsolete on the back of the last whorl which is entirely smooth except for the spirals about the base and canal. *S. matima* resembles *S. Bassi* Maury, from the Miocene of Santo Domingo but is more slender and has a great many more ribs.

Gatun Stage: Hill 1a, Banana River.
Coll. 7, Estrella River.

Strombina cricamola, n. sp. Plate 10, figure 18

Shell ovate, solid, with a large, convex and spirally sculp-

tured body-whorl and a long attenuated spire; whorls 6 plus (apex broken so that at least one complete whorl is lost from the type specimen); the first 4 whorls are smooth, after which a few incised spiral lines appear just below the upper suture; these spirals gradually increase in strength and in number and on the following whorls have become strong, raised spiral cords; the penultimate whorl has 5 spirals, the last about 24 (including those of the anterior canal); the upper half of the last whorl and sometimes the penultimate, are longitudinally plicated with 18 rib-like costæ; aperture narrow, with a thickened outer lip, notched above and obsoletely denticulated below; the inner lip is smooth; canal short, twisted.

Length 16, diameter 8.5, aperture 9, spire 7 mm.

An unusually short and broad species, distantly related to the *C. pulcherrima* Sowerby, recent from the Gulf of Dulce. Two specimens were collected from the Gatun sandstones of Water Cay.

Gatun Stage: Water Cay.

Strombina costaricensis, n. sp. Plate 10, figures 8, 17

Shell solid, ovate, with a long attenuated spire; last whorl, large, flattened or contracted about the middle; whorls about 9½; the first 6 whorls are smooth and form the long attenuated spire; faint longitudinal plicæ appear on the 7th, which increase in size and form the rib-like costæ on the later whorls; axial ribs persistent and number on the last whorl about 15; the spirals begin shortly after the first appearance of the longitudinal plicæ as faint incised lines near the upper suture; these spiral lines are further increased by the introduction of more lines below and become on the following whorls raised spiral cords; the penultimate whorl has 5 or 6 spirals, the last with about 20; the spirals vary in strength on individual shells and on some specimens may be lacking from the middle of the whorl, forming a smooth median band; aperture linear, small and coutracted and with a calloused inner and outer lip ; outer lip strongly thickened, notched above and feebly dunticulated below; canal short, straight.

Length 15.5, diameter 7.5, spire 8, aperture 8 mm.

A species with an *Anachis*-like sculpture, the ribs and generally the spirals being persistent. The body-whorl is flattened or slightly contracted about the middle, but less so than in the following variety. A long, tapering and nearly smooth spire as in the preceding *S. cricamola* but much more slender and attenuated.

Gatun Stage: Headwater of Middle Creek, C. R.

Strombina costaricensis, var. **musanica**, n. var. Plate 10, figures 26, 27

Shell ovate, with a long, conic spire of 8 or more whorls; last whorl strongly contracted or indented about the middle; the first 3 whorls or more (apex broken) are smooth or sculpturless; on the following 3 whorls, the sculpture is largely of numerous, straight rib-like costæ, the spirals being only very faint and indistinct; on the last whorl the ribs number about 14; spirals about 9 on the penultimate whorl as faint raised threads and on the last whorl may be lacking from the middle or contracted zone; aperture linear-ovate, a thickened outer lip with 3 faint denticles below the upper notch; canal straight.

Length 15, diameter 6.5, spire 13, aperture 8 mm.

Probably a distinct species from the preceding and differing in its more evenly tapering and more strongly sculptured spire, and deeply contracted body-whorl. It resembles somewhat the figure of *S. cartagensis* Brown and Pilsbry from Colombia, but is smaller and has more numerous ribs. The periphery of *S. cartagensis* is rounded.

Gatun Stage: Banana River, C. R.
East fork of Red Cliff Creek.

Strombina sincola, n. sp. Plate 10, figures 19, 21

Shell small, with a large, conic spire and a dorso-ventrally flattened body-whorl; whorls about 8, the first 3 belonging to the small, smooth, pointed nucleus; sculpture of the post-nuclear whorls of numerous, straight, strong, longitudinal ribs, which are

persistent to the penultimate whorl, but are laking from the last whorl which is smooth and polished; the penultimate whorl has about 15 ribs; the ribs are generally beaded about their upper extremities; sutures distinct; last whorl large and strongly laterally flattened between a prominent ridge or hump on the left-hand side of the whorl and the large outer lip; aperture subelliptical with a large, expanded outer lip, deeply indented behind; canal short and beak-like and spirally striated with about 8 threads on the back.

Length 7, diameter 3.25, spire 3.50, aperture 3.75 mm.

A small species abundant in the Gatun beds of Hill 1a, of the Banana River. The last whorl is rather small and strongly flattened dorso-ventrally. The spire is large and about ½ of the total length of the shell.

Gatun Stage: Hill 1a Banana River.
Hill 3, Banana River.

Strombina chiriquiensis, n. sp. Plate 10, figures 14, 24

Shell small and in genral characters like the preceding but with a larger body-whorl and a shorter, more conic spire; whorls about 8, of which the first 3 are smooth and belong to the small pointed nucleus; the succeeding whorls until the penultimate are sculptured with fine, straight, longitudinal ribs, there being 19 on the penultimate whorl; the last whorl is rather large, smooth and dorso-ventrally flattened between a hump-like ridge on the left side and the large, expanded outer lip; canal short, beak-like and spirally striated; aperture linear-ovate, deeply indented behind; inner and outer lips are both heavily calloused, especially about their posterior portions; over this callous and between the outer and inner lips passes the small posteriorly directed canal; lower half of the inner and outer lips denticulated with 8 or 9 strong, denticles, heaviest above.

Length 7.50, diameter 4.25, spire 2.50, aperture 4.50 mm.

Of much the same size and general characters as *S. sincola* of

Costa Rica, but with a larger and broader body-whorl, and a shorter, more conic spire. The porterior portion of the inner and outer lips are heavily calloused, a feature not developed in *S. sincola*.

Gatun Stage: Water Cay.

Genus **MUREX** Linnæus

Murex messorius Sowerby

Murex messorius Sowerby, 1840, Proc. Zool. Soc. London, p. 137.

Murex recurvirostris Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 201. Not *M. recurvirostris* Broderip.

Murex messorius Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila. vol. 63, p. 353.

Murex messorius Maury, 1917, Bull. Amer. Pal., vol. 5, p. 265, pl. 16, figs. 1, 2.

This is the common *Murex* in Costa Rica. It is generally small, seldom exceeding 40 mm in height. Each whorl carries three primary varices, between which are 3 or 4 smaller ribs or costæ. It is a recent species in the West Indies.

Gatun Stage: Gatun, C. Z.
Water Cay, Panama.
Zone 5, Red Cliff Creek.
Coll. 7, Pumbri Creek.
Banana River.

Subgenus **PHYLLONOTUS** Swainson

Murex cornurectus Guppy

Murex (*Chicoreus*) *megacerus* Gabb, 1873, Trans. Amer, Phil. Soc., vol. 15, p. 202. Not *M. megacerus* Sowerby.

Murex cornurectus Guppy, 1876, Quart. Journ. Soc. London, vol. 32, p. 521, pl. 28, fig. 4.

Murex (*Phyllonotus*) *cornurectus* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 267, pl. 16, figs. 9, 10.

A large species, possibly identical with the recent *Murex brevifrons* Lamarck. The varices are large and cross the spire whorls in a spiral direction. Between the varices, there is generally a single rib-like elevation in the middle of the whorl.

Gatun Stage: Coll. 4, East Grape Point Creek.
Coll. 5, Bed Cliff Creek.
Rio Betey.
Sousi Creek.

Genus **TYPHIS** Montfort

Typhis alatus Sowerby Plate 10, figure 15

Typhis alatus Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 48, pl. 10, fig. 4.

Typhis alatus Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 203.

Typhis alatus Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 522.

Typhis alatus Brown and Pilsbry, 1911, Proc. Acad. Nas. Sci. Phila., vol. 63, p. 354.

A very characteristic species distinguished by the large wing-like expansion of its outer lip. It is the largest species in the Gatun and measures about 23 mm in height by 17 mm in diameter. It is found also in the Miocene of Santo Domingo and in the Bowden beds of Jamaica.

Gatun Stage: Gatun, C. Z. (Brown and Pilsbry)
Toro Cays, Panama.

Typhis linguliferus Dall, var. **costaricensis**, n. var. Plate 10, figs 22, 29

cf. *Typhis linguliferus* Dall, 1890, Trans. Wagner Free Inst. Sci., vol. 3, pt. 1, p, 152, pl. 12, fig. 7.

This is a smaller and more delicate species than the *T. Gabbi* Brown and Pilsbry from the Canal Zone. They agree with the Chipolan *linguliferus* Dall in their general form but differ in their uniformly smaller size and in nearly lacking the spine-like pro-

cess on the shoulder of primary varices. It is fairly abundant in the Gatun beds of the Banana River.

Gatun Stage; Hill 1a, Banana River.

Genus **SISTRUM** Montfort

Sistrum nodulosum C. B. Adams Plate 10, figure 23

Purpura nodulosa C. B. Adams, 1845 Proc. Bost. Soc. Nat. History, p. 3.

Ricinula nodulosa Tryon, 1880, Manual of Conch., vol. 2, p. 190, pl. 59, fig. 275.

Sistrum nodulosum Dall and Simpson, 1901, Bull. U. S. Fish. Com., vol. 1, p. 411.

Worn specimens of the species occur in the transitional beds of Red Cliff Creek. They cannot be separated from recent examples from the present coast. It is very common as a recent species on the rocks and reefs along the northern Costa Rican and Panama coast, where it occurs about high-water level, associated with the equally as abundant *Engina turbinella* Kiener and *Phasianella affinis* C. B. Adams.

Uscari and Gatun transitional beds; Zone 5 and 6, Red Cliff Creek.

(C) *SUPER-FAMILY TÆNIOGLOSSA*

Genus **DISTORTRIX** Link

Distortrix simillima Sowerby

Triton simillimus Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 48.

Persona simillima Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 288, pl. 17, fig. 13.

Distortia simillimus Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 212.

Persona simillima Guppy, 1874, Geol. Mag., p. 439.

Persona simillima Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 35, p. 522.

Distorsio (*Distortrix*, *Persona*) *gatunensis* Toula, 1908, Jahrb. der K-K Geol. Reichsanstalt, Wien, vol, 58, p. 700, pl. 25, fig. 10.

Distorsio gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phil., vol. 63, p. 356, pl. 29, fig. 8.

Distortrix simillima Maury, 1917, Bull. Amer. Pal., vol. 5, p. 271, pl. 17, figs. 4, 5.

Not common in Costa Rica. It also occurs in the Miocene of Jamaica and Santo Domingo.

Gatun Stage; Gatun, C. Z.
Banana River.
Port Limon.

Genus **BURSA** Bolten

Bursa crassa Dillwyn — Plate 15, figure 15

Ranella crassa Dillwyn, Reeve, Conch. Icon.,fig. 18.

Ranella crassa Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 288, pl. 18, fig. 9.

Bursa crassa Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 212.

Ranella crassa Guppy, 1874, Geol. Mag., p. 438.

Ranella crassa Guppy, 1876, Quart. Jouru. Geol. Soc. London, vol. 32, p. 522.

Bursa crassa Maury, 1917, Bull. Amer. Pal., vol. 5, p. 272, pl. 17 figs. 6, 7.

This is a recent species in the West Indies. It occurs also as a Miocene fossil in Jamaica and Santo Domingo.

Gatun Stage: Banana River.
Saury Creek.

Genus **CASSIS** Lamarck

Cassis sulcifera Sowerby

Cassis sulcifera Sowerby, 1849, Quart. Journ. Geo l. Soc. London, vol 6. p. 47, pl. 10, fig. 1

Cassis sulcifera Maury, 1917, Bull. Amer. Pal., vol. 5, p. 274, pl. 18, figs. 1, 2. 3.

This is a large species very common in Miocene rocks of Santo Domingo but very rare in Costa Rica. Our record is based on a single imperfect specimen from the Banana River and for a figure of this species the reader is referred to Dr. Maury's Dominican Fossils.

Gatun Stage: Hill No. 3, Banana River.

Cassis flammea Linnæus

Buccinum flammeum Linnæus, 1758, Syst. Nat., ed. 10, p. 736.

Cassis flammea Reeve, 1848, Conch. Icon., vol. 5, pl. 5, fig. 12.

Cassis flammea Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 356.

This is a recent species recorded by Gabb, from his so-called Pliocene clay beds of Costa Rica. Under this term, Gabb confused two formations, one composed largely of coralline limestones but with subordinate amounts of clays and sands equivalent in large measure to the Gatun formations, and an overlying, mostly sand and clays of true Pliocene age. It is most likely that the single example of *Cassis flammea* collected by Gabb, was obtained from the upper or Pliocene formation.

Subgenus **PHALIUM** Link

Phalium moniliferum Guppy Plate 12, figure 11

Cassis monilifera Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 287, pl. 17, fig. 8.

Casidea granulosa Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 222. Not *C. granulosa* Bruguiere.

Cassis reclusa Guppy, 1874, Geol. Mag., London. pp. 434, 439.

Cassis reclusa Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 525.

Cassis monilifera Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 525.

Phalium moniliferum Maury, 1917, Bull. Amer. Pal.. vol. 5, p. 274, pl. 18, figs. 4, 5; pl. 19, fig. 1.

The Costa Rican specimens like those of Santo Domingo are extremely variable in their sculpture. The typical *moniliferum* of Jamaica carries on the shoulder of the body-whorl one or two rows of large tubercles or granules and Guppy's figure shows the spirals below as finely granulated.

In Costa Rica, the shells may vary from those with nearly smooth spirals, through transitional forms in which only the superior bands are granulated, to the extreme in which all the spirals are finely granulated over the whorl shell. A typical specimen will average:

Length 35, diameter 22 mm.

Gatun Stage: Middle Creek.
Rio Beley.
Zone 5, Red Cliff Creek.

Genus **SCONSIA** Gray

Sconsia laevigata Sowerby, var. **Gabbi**, n. var. Plate 12, figure 3

cf *Cassidaria laevigata* Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 47, pl. 10, fig. 2.

cf *Cassidaria sublaevigata* Guppy, 1866, *Idem*, vol, 22, p. 287, pl. 27, fig. 9.

Cassidaria laevigata Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 356.

cf *Sconsia sublaevigata* Bose, 1906, Bol. Inst. Geol. de Mexico, Numero 22, p. 36, pl. 4, figs. 9, 10.

Sconsia laevigata Prown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila. vol. 63, p. 356.

cf *Sconsia laevigata* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 275, pl. 19, fig. 2.

As Gabb noted years ago, the Sconsias of Costa Rica are not the typcal *laevigata* of Santo Domingo but appear to approach more closely in their striated whorls, the Jameican *sublaevigata* of Guppy and the recent *striata* of Lamarck.

Typical *laevigata*, has generally a distinct shoulder to its

body-whorl and a lower spire. The spire-whorls are striated but the spirals are lacking from the generally polished body-whorl. The aperture of *laevigata* is subrectangular in outline, rather wide anteriorly and flaring posteriorly, while in *Gabbi*, the aperture is narrow and but little larger anteriorly. In *laevigata*, the callus of the inner lip is large and spreads widely over the columellar area, but its outer edge is raised and shelf-like, instead of rounded and appressed as in *Gabbi*. Mature shells of *laevigata*, have three large, heavy varices, marking the resting stages but such varices are small and sometimes entirely lacking from the Costa Rican shells.

Typical *laevigata* will probably be found to be largely limited to Santo Domingo. The Jamaica *sublaevigata* (possibly a variety) has more strongly sculptured whorls, a short spire and less complete varices. Its aperture is that of true *laevigata*.

The *Sconsia laevigata* was found by Dr. Maury, in her work on the Paleontology and Stratigraphy of Santo Domingo to be limited to her upper or Gürabo formation (the-*Sconsia laevigata* zone). In Panama and Costa Rica, the *Sconsia laevigata* variety *Gabbi*, is frequently very abundant in the Gatun beds, but it is apperently lacking from the underlying Uscari shales where it is replaced by the new *Sconsia cocleana* and probably *bocasensis*.

Gatun Stage: Gatun, C. Z.
Toro Cay, Water Cay, Panama.
Comadre Creek near Cahuita C. R.
Rio Blanco, C. R.

Sconsia bocasensis, n. sp. Plate 12, figures 12, 13

Shell like that of *laevigata*, but narrow and with coarsely sculptured whorls; spire more evenly conic, the apex of which is not produced or attenuated; whorls coarsely sculptured with heavy, persistent spirals threads, of which there are about 9 on the spire-whorls and nearly 50 on the last whorl; sutures appressed and bordered anteriorly by a strong ridge-like cord or by stronger spirals; the varices are but slightly developed; aperture subellip-

tical, widest about the anterior 1-3; outer lip thickened and with about 18, fine, liræ-like denticles ; the inner lip with a thin spreading callus and with about 16 long, narrow rugations.

Length 35 (last 2 whorls only) diameter 25 mm.

Differs from the variety *Gabbi* of *laevigata* by its more narrow shell, coarser sculpture and larger aperture. The suture is bordered by a cord-like ridge.

Gatun Stage: Bocas del Toro.

Sconsia cocleana, n. sp. Plate 12, figure 7

Shell globose; spire low of about 7 whorls, the apex slightly projecting; sutures distinct and deep, but not appressed; surface coarsely sculptured with large, irregular, but narrow spirals bands separated by deep interspaces which may in addition carry one or more finer spiral threads; there are 7 or 8 spirals on each spire whorl; on the last whorl the spirals are nearly twice as wide as the upper third of the whorl and more anteriorly; no varices; the outer lip is broken from the single specimen; inner lip is a wide but thin wash of callus, without rugations or denticles of any sort.

Length 46, diameter 32 mm.

The Uscari shales which everywhere in Costa Rica appear to underlie the Gatun sandstones is very rich in the smaller types of foraminifera, but mollusks are rare, fragmentary and difficult to collect. Fragments of *Sconsia*, were noted by us at several places which we believe belong to this species or to the *bocasensis*.

This species will be recognized by its broad, globose shell and small spire. It lacks the sutural cord so strikingly developed on *bocasensis*.

Uscari Stage: Rio Cocles near Old Harbor, C. R.

Genus DOLIUM Lamarck

Subgenus MALEA Valenciennes

Malea elliptica Pilsbry and Johnson Plate 12, figure 2

Malea elliptica Pilsbry and Johnson, 1917, Proc. Acad, Nat. Sci. Phila., vol. 69, p. 169.

The true *Malea camura* Guppy, so common in the Miocene of Jamaica and Santo Domingo still remains to be collected in Costa Rica. It is usually a smaller species (height 60 mm) with a heavier shell and high, narrow, special bands numbering about 16 or 17 rather widely separated.

The *M. elliptica* is larger (height 60-80 mm or more), more globose and thin. The spiral bands numbering about 22 are closely spaced and ribbon-like. The coiling is regular, while in *camura* the coiling is irregular and descending in the latter stages of growth.

The *Malea elliptica* was described but not figured by Johnson and Pilsbry from the Miocene of Santo Domingo.

Height 63, diameter 54 mm.

Uscari Stage: Red Cliff Creek.

Gatun Stage: Bocas del Toro. Estrella River. Hill 1a, Banana River.

Genus CYPRAEA Linné

Cypraea parisimina, n. sp. Plate 12, figure 10

Shell small, more or less depressed and with expanded, angulated sides; dorsal surface convex, but with a deep pit or depression at its posterior end, beyond which project the 2 short, pouting ends of the lips of the aperture; ventral surface flat, with a narrow aperture which is straight except near at its posterior end where it is slightly curved; lips strongly but regularly crenulated (about 21 on each lip) posterior sinus

small and curved to the left; anterior sinus small and rounded.

Length 39, basal diameter 25, height or vertical diameter 17 mm.

A small shell with strongly depessed and angulated sides. Collected from the coral limestones of Port Limon.

Gatun Stage: Port Limon,

Cypraea cf. dominicensis Gabb

Cypraea Dominicensis Gabb, 1873, Amer. Phil. Soc., vol. 15, p. 236.

Cypraea dominicensis Maury, 1917, Bull. Amer. Pal., vol. 5, p. 280, pl. 19, fig. 11

Our collection contains a single, fragmentary shell from the coralline limestones near Limon. This specimen agrees closely with the Dominican shell figured by Dr. Maury as *C. dominicensis?*. It is characterized by its very thin shell, cylindroid form and straight, evenly denticulated apertrue.

Length 28, height 12 mm.

Gatun Stage: Port Limon.

Cypraea cinerea Gmelin Plate 12, figure 8

Cypraea cinerea Gmelin, 1792, Syst. Nat., p. 3404.

Cypraea cinerea Reeve, Icon., vol. 3, pl. 22, fig. 124.

Cypraea cinerea Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 360.

The *Cypraea cinerea* is a common, small species of Cowry shell along the north coast of Panama and Costa Rica. Several small Cypraeas were collected from the Gatun sandstones of the Rio Blanco which cannot be distinguished from recent examples of *cinerea*.

Gatun Stage: Rio Blanco.

Cypraea almirantensis, n. sp. Plate 12, figure 9

Shell large, heavy and rather high; the outlines of the shell

from below, the side and from above is nearly rectangular, but with the anterior extremity more pointed; the shell is high (about ½ that of the length), with nearly flat or slightly convex sides; dorsal surface convex, a deep depression or pit about the posterior 1-4 and low, but large tubercles on each side of the posterior sinus; aperture narrow, curved, with the lips coarsely but regularly dentate (about 20 on each lip); posterior sinus is long and vertical; anterior sinus small and rounded; basal surface flat.

Length 60, basal diameter 39, vertical diameter 30 mm.

This is a species but distantly related to the *C. Henkeni* Sowerby, differing by its longer and higher shell, straight sides and smaller dorsal tubercles. The aperture is strongly curved and very deep on the posterior extremity, ending in the long, vertical sinus.

Gatun Stage: Water Cay, Panama.

Genus **STROMBUS** Linnæus

Strombus gatunensis Toula — Plate 13, figures 5, 6

Strombus gatunensis Toula, 1909, Jahrb. der K-K Geol. Reichsanstalt Wien, vol. 58, p. 673, pl. 25, fig. 7.

Strombus gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 355, pl. 26, figs. 3, 5.

But two species of *Strombus* are known from the Gatun beds of Panama and Costa Rica, while five species occur in the synchronous Miocene strata of Santo Domingo and four in Jamaica. Other species may therefore be expected with further exploration work in Costa Rica.

In *S. gatunensis*, the coiling of the whorls follow closely the shoulder angle so that the last whorl appears very large and the spire low but wide. Young shells occasionally have the shoulder armed with few, large tubercles which later become nearly covered by the close coiling and appressed sutures. The last whorl is large, nearly smooth and with a rounded shoulder angle.

Occasionally traces of the original coloration is preserved

and consists of narrow, yellow V-shaped lines, the acute base of which are directed backwards or away from the aperture and lie along the center of the whorls. Similiar markings may be seen on *Veatchi* and Guppy* has described the same markings for *pugiloides* from Jamaica. Length 63, diam. 42 mm.

Gatun Stage: Gatun, C. Z.
Water Cay, Panama.
Headwaters of Middle Creek, C. R.

Strombus pugiloides Guppy Plate 13, figures 1, 2, 3

Strombus pugilis Guppy, 1866, Quart. Geol. Soc. London, vol. 22, p. 287.

Strombus pugilis Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 233.

Strombus pugiloides Guppy, 1874, Geol. Mag., new series, vol. 1, p. 433.

Strombus pugilis Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, p. 340.

Strombus pugilis Bose. 1906, Boll. de Inst. Geol. de Mexico, numero 22, p. 35, pl. 4, figs. 1-6.

Strombus pugiloides Maury, 1917, Bull. Amer. Pal., vol. 5, p. 284, pl. 20, fig. 6.

A smaller species than the *gatunensis*, from which it also differs by its longer spire and more strongly sculptured shell. The coiling follows below the shoulder of the whorls, which is either simply rounded or bears several large, spine-like tubercles as in the recent *pugilis*. Resting stages develop large, hump-like areas irregularly distributed on the spire-whorls. Varieties occur which may be spirally sculptured over the whole shell or the last whorl may be largely smooth. The original coloration is still preserved on some shells and consist as in *gatunensis* of narrow, yellow, V-shaped lines, the apex of which lie about the middle of the shell and directed backwards. It is very distinct from the recent West Indian *pugilis*, which does not appear to descend below the Pliocene.

* Proc. Sci. Assoc. Trinidad, 1873, vol. 2, p. 82, (reprint: Bull. Amer Pal., vol. 8, p. 214).

Uscari Stage: Sapote, C. R. (Gabb)
Gatun Stage: Banana River.
Zone E, Saury Creek.
Zoni 5, East Grape Point Creik.

Genus **CREPITACELLA** Guppy

Crepitacella limonensis, n. sp. Plate 15, figure 17

Shell small, melanoid in form, with a large body-whorl and shorter conic spire; nucleus of 2 small, smooth whorls followed by 5 post-nuclear whorls; sutures distinct; the whorls are slightly coronated and crossed by oblique and slightly curved riblets which become headed on the coronate edge of the spire-whorls just below the upper sutures; on the last whorl, the ribs do not pass below the middle; the surface is covered with faint spiral threads, most distinct on the base of the body-whorl; aperture elliptical, with a thin, oblique outer lip and a subobsolete anterior canal; pillar straight.

Height 8, diameter 4.5, aperture 4 mm.

The Costa Rican shell, although possibly not mature, is much smaller than the *C. cepula* Guppy from the Miocene of Venezuela and Santo Domingo of the same number of ribs. It differs also in having but 2 nuclear whorls, while *cepula* has 3. The coronation of the whorls which is such a striking feature of the Dominican shell, is very much less and inconcpicuous. The longitudinal costæ are more numerous and produce a fine circle of beads as they cross the small coronate edge of the spire-whorls.

Gatun Stage: Port Limon,
Boras del Toro.

Genus **CERITHIUM** Adanson

Cerithium costaricensis, n. sp. Plate 10, figure 28

Shell with a long, slender spire of about 12 whorls (tip broked); sutures deep but somewhat appressed; the profile of the

spire-whorls is convex with an occasional hump-like resting mark; the sculpture consists of primary spiral threads between which lie 1, 3, or more finer secondaries; the earlier spire-whorls have heavy ribs but they become replaced on the later by simple granulations on the primary spirals; a narrow, sloping band borders the anterior side of the suture and carries finer, non-beaded spiral threads: below this band, the later spire-whorls bear about 4 beaded, primary spirals and finer secondaries; the last whorl shows 6 primaries together with other spirals on the base and canal; aperture subcircular, with a moderately expanded outer lip, obliquely produced anteriorly.

Height 28, diameter 10.5, aperture 8 mm.

The general form and sculpture of this species is that of the recent West Indian *C. eburneum* Bruguiere. The fossil shell is larger, more slender and differently sculptured.

Gatun Stage: Coll. 6, Red Cliff Creek.

Genus **CLAVA** Martyn

Clava costaricana, n. sp. Plate 10, figures 3, 4

Shell of medium size, cerithoid; whorls about 15, the early spire-whorls very small; the last whorl carries a large hump on the ventral side of the shell to the right of the aperture, so that the shell appears flattened on this side; the sculpture consists of strong spiral cords which are coarsely granulated by small, closely spaced longitudinal costæ; the upper spiral cord bordering the suture is somewhat larger than the other; there are 3 spirals between the sutures of the spire-whorl and 6 on the last whorl with additional smaller ones on the base of the shell; the outer lip is broken on all our specimens; the columella carries 2 strong folds.

Height 40, diameter 15 mm.
41, 14 mm.

This species bears some resemblance to the *C. caloosaënsis* Dall from the Pliocene of Florida. The Costa Rican shell is

very much larger, broader and the longitudinal costæ are more rib-like, continued across the whorls, crossing the interspaces as well as the spiral cords.

Gatun Stage: Banana River.

Clava alajuela, n. sp. Plate 10, figure 30

Shell small, slender; whorls 12 plus, the apex broken; the sides of the whorls are straight and form the narrow, tapering spire; sutures indistinct; the sculpture consists of nearly equal ribs and spiral threads; the early spire-whorls have 3, equal, spiral threads, separated by interspaces as wide as the spiral threads and deep; on the later whorls fine, intermediate threads appear in the interspaces and a fourth large spiral in the lower suture; the spirals are crossed and strongly beaded by straight or slightly curved, longitudinal ribs, which number on the last whorl about 25 or 24; heavy and thickened resting marks appear on the later whorl on each volution; the aperture is broken, the columella straight and with a single small fold.

Height 17 mm, diameter 6 mm.

A small and finely sculptured species, represented by the single type specimen.

Gatun Stage: Middle Creek.

Genus **SERPULORBIS** Sassi

Serpulorbis papulosa Guppy Plate 12, figure 1

Vermetus papulosus Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 292, pl. 17, fig. 3.

Vermetus papulosus Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 519.

Sespulorbis papulosa Maury, 1917, Bull. Amer. Pal., vol. 5, p. 291, pl. 22, fig. 10.

Considerable variation may be seen in the Costa Rican shells, from specimens in which the sculpture is quite coarse and with the interspaces between the main cords carrying only one strong

intermediate cord, to more delicately sculptured forms with finer tuberculated cords separated by wide and finely sculptured interspaces.

This species occur also in the Bowden beds of Jamaica and in the Gurabo formation of Santo Domingo.

Gatun Stage: Hill 1, 2, Banana River.

Genus **PETALOCONCHUS** H. B. Lea

Petaloconchus sculpturatus, H. C. Lea Plate 14, figures 10, 15

Petaloconchus sculpturatus H. C. Lea, 1845, Trans. Amer. Phil. Soc., vol. 9, p. 233, pl. 34, fig. 3.

Petaloconchus domingensis Sowerby, 1849, Quart. Journ. Geol, Soc. London, vol. 5, p. 51, pl. 10, fig. 8, a b c.

Pataloconchus sculpturatus Gabb, 1875, Trans. Amer. Phil. Soc., vol. 25, p. 240.

Pataloconchus sculpturatus Guppy, 1876, Quart. Journ. Geol. Soc. London, vol. 32, p. 519.

Vermetus (*Petaloconchus*) *sculpturatus* Dall, 1892, Trans. Wagner Free Inst. Sci., vol. 3, pt. 2, p. 305.

Vermetus (*Petaloconchus*) *pulcher* Bose, 1906, Bol. Inst. Geol. de Mexico, Numero 22, p. 32, pl. 3, figs. 22, 23.

Petaloconchus domingensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 359.

Petaloconchus domingensis Pilsbry and Brown, 1917, Proc. Acad. Nat. Sci. Phila., vol. 69, p. 37.

Petaloconchus domingensis Maury, 1917, Pull. Amer. Pal., vol., 5, p. 292, pl, 22, fig. 11.

Pataloconchus domingensis Hubbard, 1920, New York Academy of Science, Sci. Sur. P. R., vol. 3, pt, 2, p. 139.

The Antillean fossil was described by Sowerby as *domingensis*. It has been by some writers, considered synonymous with *sculpturata*, described a few years earlier by H. C. Lea from the Chesapeake Miocene of the eastern United States, while others have given *domingensis* the rank of a full species. A close comparative study of the Costa Rica fossils with several sets of typi-

cal *sculpturata* reveals no distinction between them. Both are variable in their coiling from closely wound, narrow cylinders to more open, umbilicate coils. The sculpture is much the same.

In the United States, this fossil is limited to the Upper Chesapeake Miocene. In the Antillean and South American regions, it is found in the Bowden beds of Jamaica, the Gurabo formation of Santo Domingo, the Quebradillas limestone of Porto Rico, the Springdale beds of Trinidad, from the Gatun beds near Cartagena, Colombia and Mexico.

Gatun Stage: Gatun Stage, C. Z.
Water Cay, Panama.
Coll. 4, 5, East Grape Point Creek.
Comadre Creek.

Genus SILIQUARIA Lamarck

Siliquaria modesta Dall, var. **limonensis,** n. var, Plate 12, figure 4, 5, 6

cf *Siliquaria modesta* Dall, Mus. Comp. Zool., vol. 9, p. 39.

cf *Siliquaria modesta* Dall, 1889, Bull. Mus. Comp. Zool., vol. 18, p. 260, pl. 26, fig. 4.

This shell is very abundant in certain marly and sandy beds in the coralline limestones of the Limon Peninsula and elsewhere. Specimens in perfect condition are very difficult to obtain, the shell being very fragile and delicate. There are no longitudinal threads and the shell is smooth, except for the growth lines which are sometimes a little irregular.

We have associated this shell with the *S. modesta* of Dall, a recent species and recorded by Dr. Dall from several stations in the West Indies and the Gulf of Mexico, in waters ranging from 94 to 805 fathoms in depth. The fossils differ in being more loosely coiled and at the later stages long drawn out.

Dr. Maury's *S. guarabensis* from the Miocene of Santo Domingo is more irregular in its habitus of growth and the surface of the shell carries faint longitudinal threads. Gabb has des-

cribed as *sculpturata* a *Siliquaria* from the Limon Peninsula. This is united by Dall with the recent West Indian *squamata* Blainville. I have seen no spicimens and Gabb may have collected it from the true Pliocene beds of the Limon Peninsula.

Gatun Stage; Island of Bocas del Toro.
Port Limon.

Genus **TURRITELLA** Lamarck

Turritella gatunensis Conrad — Plate 14, figures 12, 13

Turritella gatunensis Conrad, 1857, Pacific R. R. Report, vol. 6, p. 72, pl. 5, fig. 20.

Turritella conradi Toula, 1909, Jahrb. der K-K Geol. Reichsanstalt, vol. 58, p. 694, pl. 25, fig. 4.

Turritella gatunensis Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, pl. 27, figs. 4, 5, 9.

The *Turritella gatunensis* is a medium sized shell seldom over 40 mm in length. The base of the whorl overhangs the next, and each whorl is encircled by a median concave or constricted band. The whole surface it finely sculptured with small spiral threads. The spirals defining the median band are usually slightly heavier as well as a few about the upper part of the base.

The *T. gatunensis* is a common and widely distributed species in the Gatun beds, but always less abundant than the *T. altilira* or its varities. Like the *altilira*, zones of *T. gatunensis* are frequent in some localities.

The *T. atacta* Dall of the Tampa Silex beds, the *T. acropora* fossil in the Pliocene of Florida and recent along the east coast of United States and the West Indies, are related species.

Gatun Stage: Gatun, C. Z.
Water Cay, Panama.
Boucary Creek, C. R.

Turritella mimetes Brown and Pilsbry Plate 14, figure 5

Turritella mimetes Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 357, pl. 27, fig. 1.

Turritella (*Haustator*) aff. *Hanleyana* Reeve - *T. lineolata* (Kiener) Toula, 1911, Jahrb. der K-K Geol, Reichsanstalt, vol. 61, p. 401, pl. 30, figures 6a and 6b,

A large, robust species in form and sculpture like the *T. variegata* Linnæus, recent in the West Indies.

The whorls are straight and usually slightly overhanging the lower sutures. Surface sculptured with primary, secondary and tertiary spiral threads. The primary threads are irregularly disposed and usually number about 7 or 8 to each whorl. Between the primaries are the finer secondaries and tertiaries.

Small shells may be mistaken for the *gatunensis*, but the whorls are flat, without the median concave and constricted zone and the sculpture is more coarse. The figured shell of 14 whorls has a length of 70 mm and a diameter of 18 mm. A larger but more imperfect specimen of but 4 whorls measures:

Length 50, diameter 20 mm.

Gatun Stage: Gatun, C. Z.

Turritella altilira Conrad, and varities.

Turritella attilira Conrad, 1857, Pacific R. R. Reports, vol. 6, p. 72, pl. 5, fig. 19.

Turritella gabbi Toula, 1909, Jahab. der K-K Geol. Reichsanstalt, p. 695, pl. 25, fig. 5.

Turritella altilira Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 358, pl. 27, figs. 2, 3.

Of the species of *Turritella* in the Gatun beds of Costa Rica and Panana, the *T. altilira* of Conrad and its varieties is the most common and characteristic. The *T. tornata* Guppy, from the Miocene of Trinidad and Venezuela is a closely related species.

These magnificent *Turritellæ* are preminently characteristic of the West Indian and Caribbean Miocene, but probably derived from earlier forms in the Oligocene. The stock continued in-

to the Pliocene where its acme of development was reached in the elegant *T. preattenuata* Heilprin of Florida. It has left no descendants in the recent fauna.

The shell is long and tapering, each whorl sculptured with 2 prominent beaded spiral cords, between which the surface is concave or deeply channeled and may be smooth or with finer spiral threads. The upper spiral cord is simple or double. Several varieties may be recognized which differ in details of their sculpture, size and form of shell.

T. altilira Conrad, typical Plate 14 figures 6, 7

This, the most elegant form is limited to the small Gatun sedimentary basin of the Canal Zone and the adjacent Province of Colon.

The shell is long, slender and with numerous whorls; each whorl is strongly sculptured by the two, primary spiral cords, each of which is bordered on adjacent faces by a smaller spiral, between which lies a deeply channelled groove; smaller beaded spirals occur in the median channel and are best developed on the spire whorls; the beading or granulation of the spirals is produced by the arcuated lines of growth, the sinus of which lies a little above the middle of the shell; the upper spiral cord is larger than the lower and more strongly beaded and in general becomes double on the later whorls.

Gatun Stage: Canal Zone and Province of Colon.

Var. **chiriquiensis**, n. var. Plate 14, figures 4, 8, 9, 14

Shell larger, less attenuated and more coarsely sculptured than typical *altilira*; the 2 spiral cords are less strong, of more nearly the same size and usually remaining simple; the 2 spiral cords enclose a wide, concave area of about ½ the width of the whorl; this concave band usually carries 2, 3, or more fine spiral threads; the beading or granulation of the spiral cords is feeble and best developed on the earlier spire whorls and in certain large,

gerontic shells the spiral cords may become nearly smooth.

This is the common form on the islands of the Chiriqui Lagoon, and of eastern Costa Rica. Like the typical *altilira* it is often a very abundant fossil, forming zones of *Turritella* in the Gatun beds.

The sculpture is much less elegant than that of true *altilira*, and consists mainly of the 2, primary spiral cords, between which lies a wide concave band. This band is but feebly sculptured by small, spiral threads, or in some cases, is smooth.

In small matters of detail of sculpture and in the form and taper of the shells, there is considerable variation. Such variation is usually of but local signifieance and in general the shells collected at the same or nearby localities will agree closly with each other but differ more or less from those of more distant areas.

The *T. tornata* Guppy from the Miocene of Venezuela and Trinidad should probably be considered as a variety of *altilira*, most closely allied to the *chiriquensis*. Its sculpture is like *chiriquensis* but with stronger spiral threads on its median band.

Gatun Stage: Water Cay.
Grape Point and Red Cliff Creeks, C. R.
Banana River.
Rio Blanco.

Var. **costaricensis**, n. var. Plate 14, figure 11

Shell small; whorls less numerous and more rapidly increasing so that the shell is porportionately broader and shorter; sutures deep; the 2 primary cords are but weakly developed, between which lies, the concave band as in *chiriquiensis;* the band carries 3, 4, or more strong, irregular spirals, but slightly weaker than the primaries; the granulation of the cords is weak and irregular.

Much smaller than the preceding varieties (usually about 40 mm) and with wider and more rapidly increasing whorls. The

cords on mature shells are small and but slightly heavier than the spiral threads on the concave band.

This type replaces the *chiriquiensis* in the Gatun sandstones in the area of Upper Hone Creek and Boucary Creek. It is often extremley abundant, associated with the *Turritella gatunensis*.

Gatun Stage: Upper Hone and Boucary Creeks.

Turritella exoleta Linnæus, var. **limonensis**, n. var. Plate 14, figs 2, 3

Shell turreted, the whorls increasing more rapidly in diameter than typical *exoleta;* the nucleus is small, immediately followed by whorls carrying a median carina which gradually becomes more anterior in position and later the lower carina of the adult sculpture; the whorls are deeply concave or excavated about the middle between 2 principal carinæ; on the last whorl there is seen to be a third carina which is concealed in the suture; the sutures are excavated, becoming generally deeper with age; the surface is nearly smooth, except for very faint spirals and rough growth lines which may be raised and sublamellose on the median concave zone.

Height 40 (6 later whorls) diameter 17.50 mm.
Height 35 (10 earlier whorls) diameter 10 mm.

This is probably a distinct species from the recent West Indian *Turritella exoleta* Linnæus, differing in its more rapidly expanding whorls. Faint spirals may generally be seen covering the entire shell and the growth lines become raised and sublamellose in the concave medial zone. It is a common shell in the coralline phase of the Gatun at Port Limon and elsewhere.

Gatun Stage: Port Limon.
Bocas del Toro.

Turritella oreodoxa, n. sp. Plate 14, figure 1

Shell large, solid and very slender; whorls numerous and each but slightly larger than the preceding, slightly concave or constricted about the upper 1-3, above which the edge of the

whorl is enlarged, forming a cord-like expansion about the upper suture; sutures indistinct and appressed; sculpture of fine, irregular and somewhat wavy spiral lines and indistinctly alternating in strength; growth lines as typical for *Haustator* (not visible on the base of our specimen), commence at the lower suture and pass straight and parallel to the longitudinal axis of the shell to the middle of the whorl where they become bent and continue obliquely to the left or towards the aperture to the upper suture.

Length (2½ whorls), 49, diameter 23 mm.

A very rare species and represented in our collection by only two imperfect specimens. It appears to be closely related to the *T. cartagensis* Pilsbry and Brown from the Gatun of Colombia. The full-grown Costa Rican shell was probably longer and more attenuated and each whorl is prominently elevated or ridged just in front of the lower suture.

Gatun Stage: Rio Banana beyond Hill No. 5.

Genus **ALABA** A. Adams

Alaba turrita Guppy, 1896, Proc. U. S. Nat Mus., vol. 19, p. 321, pl. 28, fig. 7.

Guppy's figure of his type specimen from Jamaica agrees very closely with our specimen from the Estrella River. The whorls are finely spiralled with low ridges which are obsolete from the upper parts of the whorls. Each whorl carries 2 or more broad, smooth varices formed during resting stages. The last whorl is strongly angulated by these varices.

Height 5, diameter 2.25 mm.

Gatun Stage: Coll. 7, Estrella River.

Genus **ARCHITECTONICA** Bolton

Architectonica granulata Lamarck Plate 13, figure 10 ,11, 12

Solarium granulatum Lamrack, 1822, An. sans. Vert., vol. 7, p. 3,

Architectonica prespectiva Tuomey and Holmes, 1857, Pleioc. Fos. S. C., p. 120, pl. 26, fig. 6.

Solarium granulatum Dall, 1892, Trans. Wagner Free Inst. Sci., vol. 3, pt. 2, p. 329.

Solarium Villarelloi Bose, Inst. Geol. de Mexico, Numero 22, p. 30, pl. 3, figs. 4-11.

Solarium gatunense Toula, 1908, Jahrb, der K-K Geol. Reichsanstalt, Wien, vol. 58, p. 693, pl. 25, fig. 3.

Solarium granulatum Maury, 1917, Bull. Amer. Pal., vol. 5, p. 295, pl. 23, fig. 3.

The Costa Rican fossils are usually quite typical and not to be distinguished from recent examples of *granulata*. They vary somewhat in their height and persistence of their spiral sculpturing. The beaded and granulated character of the spirals generally becomes obsolete on the later whorls so that the spiral bands appear smooth. The umbilicus is deep but narrow.

This is a stable species ranging from the lower Miocene to the recent. Its recent distribution extends from Cape Hatteras on the north, southward through the West Indies and on the Pacific side from the Gulf of California to Peru.

Height 20, greater diameter 43 mm.
19, 29 mm.
12.75 20 mm.

Gatun Stage: Gatun, C. Z.
Water Cay, Panama.
Coll. 2, Rio Cocles.
Banana River.
Rio Betey.

Genus **NATICA** Scopoli

Natica canrena Linnæus Plato 13, figure 9

Natica canrena Linnæus, 1758, Syst. Nat., ed. 10, p. 776.

Natica canrena Gabb, 1881, Journ. Acad. Nat. Sci. Phila., vol. 8, 2nd series, p. 357.

Natica canrena Brown and Pilsbry, 1912, Proc. Acad. Nat. Sci. Phila., p. 508,

Natica canrena Maury, 1917, Bull. Amer. Pal., vol. 5, p. 298, pl. 23, fig. 10.

This is a recent species but also common as fossil in the Miocene of the West Indies and the States. It is a warm water species so that in the Chesapeake Miocene of the eastern United States, it is found only in the warm, upper or Duplin stage. We collected several specimens at Gatun but none at Costa Rica. Gabb however has recorded it as abundant from the Limon Peninsula but whether his specimens were obtained from the Miocene or Pliocene is not known.

The species is distinguished by its strong, tangential, sutural plicæ, but the main surface of the whorl is otherwise smooth.

Gatun Stage: Gatun, C. Z.

Natica Youngi Maury, var., **cocleana**, n. var. Plate 13, figure 8

cf. *Natica Youngi* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 299, pl. 23, figs. 11, 12.

Shell subglobular with 5 rounded and convex whorls; surface smooth but with irregular, coarse growth lines about the sutures; the surface is also faintly straited with weak spiral lines as may be seen on several otherwise smooth Naticas; aperture semilunar with a narrow callus on the inner lip, slightly thicker about opposite the middle of the umbilicus; umbilicus small, with the umbilical callus small and but poorly developed.

Length or height 25, diameter 34 mm.

A single specimen from the Gatun of Cocles Creek. It agrees almost exactly with Dr. Maury's type specimen of *Natica Youngi* from the Miocene of Santo Domingo in size and form, but differs in its smaller umbilicus and smaller umbilical callus. The Costa Rican shell has the aspect of a *Neverita*.

Gatun Stage; Cocles Creek, near Old Harbor, C. R.

Section STIGMAULAX Moerch

Natica Guppyana Toula — Plate 13, figures 13, 14, 15

Natica (*Stigmaulax*) *Guppyana* Toula, 1909, Jahrb. der K-K Geol. Reichsanstalt, Wien, vol. 58, p. 696, pl. 25, fig. 6.

Natica Guppyana Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 360.

This species stands intermediate in its sculpture and form to the *N. canrena* Linnæus and *N. sulcata* Born, both recent and fossil Miocene species. In *Guppyana*, the sculpture consists of even, wide and deep sulcations, which cross the face of the whorl from the upper suture to the umbilicus. They are in fact the continuation of the tangential sutural plicæ of *N. canrena*. With further growth these sulcations may become obsolete on the middle of the whorls until they are lacking from the greater part of the shell except in the immediate vicinity of the upper sutures and on the umbilical angle. This change in sculpture is not seen to the same extent on all shells and some specimens may remain strongly grooved and sulcated even when large and mature. In other cases (in general with shells from the Banana River) only very young shells have the sulcation continuous across the face of the whorl, but soon become smooth, leaving the plications only about the upper suture and on the umbilical angle. Such shells resemble closely *N. canrena*, but in addition to the grooving of the umbilical angle, have a larger and more exanded aperture.

The *N. sulcata* Born still remains to be found in Costa Rica and Panama. It is abundant as a Miocene fossil in Santo

Domingo, Jamaica and Venezuela. It differs from the *Guppyana* by its closer and more irregular longitudinal sculpture crossed by faint spirals, producing a cancellated appearance. The umbilicus is larger and more ample.

Gatun Stage: Gatun, C. Z.
Water Cay, Panama.
Banana River, C. R.

Genus **POLINICES** Montfort

Polinices subclausa Sowerby — Plate 13, figures 16, 17

Natica subclausa Sowerby, 1849, Quart. Journ. Geol. Soc. London, vol. 6, p. 51.

Natica subclausa Guppy, 1866, Quart. Journ. Geol. Soc. London, vol. 22, p. 290, pl. 18, fig. 8.

Polinices subclausa Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Philia., vol. 63, p. 560.

Polinices subclausa Maury, 1917, Bull, Amer. Pal., vol. 5, p. 300, pl. 23, fig. 14.

This is a common fossil in the Miocene of Santo Domingo and Jamaica. The Costa Rican shells are small, the largest specimen in our collection measuring only 17 mm in altitute.

When viewed from the dorsal side, the shell has a distinctly *Nerita*-like aspect, due to its low spire, close coiling and rapidly enlarging whorls and appressed sutures. The umbilicus is of medium size, expanding below. The inner lip is provided with a thick, heavy callus which joins above with the outer lip. At the upper edge of the umbilicus, the callus carries a deep, transverse groove, a most characteristic feature.

Gatun Stage: Gatun, C. Z.
Hill No. 3, Banana River, C. R.

Polinices Stanislas-Meunieri Maury — Plate 13, figure 7

Polinices Stanislas-meunieri Maury, 1817, Bull. Amer. Pal., vol. 5, p. 300, pl. 23, figs. 15, 16.

The Banana River beds contain a large species of *Polinices* which appears to be this Dominican species. It differs from the recent *mammillaris* Lamarck, of the Costa Rican and Panama coast by its much narrow umbilicus. Its surface is lined with very fine spiral threads.

Young shells may be mistaken for the *subclausa* which occurs in the same beds, and careful study is sometimes necessary for their separation. The present shell is less heavy, with a higher spire and more convex spire whorls. The umbilicus is much narrower, and a smaller callus on its inner lip which shows but faintly the transverse groove. The surface of *subclausa* is smooth, but in *Stanislas-Meunieri* very finely lined with minute spirals.

Gabb has described from Sapote, Costa Rica, a *Natica eminuloides* which in form resembles young shells of the *Stanislas-Meunieri*. His figure shows a different shaped umilicus and no transverse groove on the callus of its inner lip.

Length or altitute 44, diameter 38 mm.

Gatun Stage: Hill 1a 2, 3, Banana River, C. R.

Subgenus **NEVERITA** Risso

Neverita nereidis Maury

Neverita nereidis Maury, 1917, Bull. Amer, Pal., vol. 5, p. 301, pl. 23, figs. 17, 18.

Our collection from ths Lower Gatun of Red Cliff Creek, contains a fragment of this very interesting species. The *N. nereidis* described by Dr. Maury, from the Cercado formation of Santo Domingo, is closely allied to the recent West Coast *N. glauca* Humboldt. The Miocene *N. nereidis* is less broad, with a narrower umbilicus and a larger umbilical callus.

Gatun Stage: Coll. 6, Red Cliff Creek, C. R.

SUB-ORDER SCUTIBRANCHIATA

A. SUPER-FAMILY RHIPIDOGLOSSA

Genus **NERITINA** Lamarck

Section **SMARAGDIA** Issel

Neritina viridemaris Maury Plates 15, figure 22

Neritina viridis Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 242, Not *N. viridis* Linnæus.

Neritina (*Smaragdia*) *viridemaris* Maury, 1917, Bull. Amer. Pal., vol. 5, p. 316, pl. 24, fig. 11.

The Costa Rican specimens are a little smaller than typical *viridemaris* from the Miocene of Santo Domingo; but are identical in other respects. They still retain their original coloration of a pale sea-green marked with straight and zigzag black lines. It is the Miocene precursor of the common, recent West Indian and Caribbean *N. viridis* Linné.

Gatun Stage: Coll. 5, Red Cliff Creek.
Middle Creek.

Genus **CREPIDULA** Lamarck

Crepidula plana Say

Crepidula plana Say, 1822, Journ. Acad. Nat. Sci. Phila., vol. 2, p. 226.

Crepidula plana Dall, 1892, Trans. Wagner Free Inst. Sci., vol. 3, pt. 2, p. 358.

Crepidula plana Brown and Pilsbry, 1911, Proc. Acad. Nat. Sci. Phila., vol. 63, p. 360.

This common and well-known species has been recorded by Brown and Pilsbry from the Canal Zone. We have a single specimen from Water Cay, found in the interior of the specimen of *Solenosteira Vaughani* var. *medioamericana*. This species first

appears in the Lower Miocene and has continued into the recent fauna.

Gatun Stage: Gatun (Brown and Pilsbry).

Genus **XENOPHORA** Fischer de Waldheim

Xenophora conchyliophora Born

Trochus conchyliophorus Born, 1778, Mus. Caes. Ind., p. 333.

Trochus agglutinans Lamarck, Anim. sans Vert., vol. 7, p. 14.

Phorus agglutinans Gabb, 1873, Trans. Amer. Phil. Soc., vol. 15, p. 241.

Xenophora conchyliophora Dall, 1892, Trans. Wagner Free Inst. Sci., vol. 3, pt. 2, pp. 360-362.

Xenophora conchyliophora, Maury, 1917, Bull. Amer. Pal. vol. 5, p. 297.

One immature shell was collected from the upper Gatun beds of Old Man Sam Creek. It is one of the few species which has continued pratically unchanged from Upper Cretaceous times to the recent. It is rare as a recent shell along the northern Panama and Costa Rican coast. Gatun Stage.

Genus **PHASIANELLA** Lamarck

Phasianella mollis, n. sp.

Shell small, solid, ovate with a short, blunt spire and a small narrow umbilicus; whorls about 4, somewhat convex; suture distinct; surface smooth and usually showing no features; in some cases, color markings are preserved as brown, wavy blotches of flammules and with very faint suggestions of fine revolving lines which are so common on recent small *Phasianella*.

Height 3.25, diameter 2.75, aperture 1.50 mm.

The *Phasianella punctata* Gabb from the Miocene of Santo Domingo, has a longer spire and different color markings It is much more like the recent *P. affinis* than the Costa Rican *mollis*. *P. mollis* is related to *P. umbilicata* d'Orbigny but differs in its sculpture.

The smaller forms of *Phasianella*, of which there are 2 or 3 species along the northern Costa Rican coast, are often extremely abundant on the rocks and reefs exposed to the heavy, pounding surf. There they are associated with a host of other gastropods, principal among which are several species of *Nerita*, *Fissurella*, *Purpura* and Chitons. The fossil shells therefore like the preceding *Neritina viridemaris* and several others which we have already called attention to, have drifted from some near-by rocky coast.

Gatun Stage: Coll. 5, Red Cliff Creek.
Middle Creek.

Genus **TURBO** Linnæus

Turbo saltus, n. sp. Plate 15, figure 12

Shell perforate, ovate-conic; spire high of about 6 convex whorls, separated by deep, canaliculate sutures; the last whorl is large and perfectly convex in form; sculpture consists of irregular, spiral cords or liræ; the earliest spire-whorls are strongly carinated by a single, strong spiral, above and below which the whorl is smooth; a second spiral appears above and the succeeding whorls of the spire have 2 principal spiral cords or liræ, and 9 smaller ones; the last whorl has three spirals that are a little stronger and many smaller ones of different sizes; the spirals are smooth; aperture perfectly circular, a small, spreading callus on the body-whorl just above the perforate base.

Height 17, diameter 15.5, aperture 7.5 mm.

Among the recent species of *Turbo* the *saltus* is related to the large *T. Spenglerianus* Gmelin, on one hand and to the smaller *T. filosus* Kiener on the other. The shell is perforate, in which character it approaches *T. filosus*, but the sutures are canaliculate or channeled as in the non-perforate *T. Spenglerianus*. The sculpture consists of irregular, smooth spiral cords or liræ of which 2 or 3 about the middle of the shell are a little larger than the others.

Gatun Stage: Coll. 5, Red Cliff Creek.

Genus **ASTRALIUM** Link

Astralium brevispinum Lamarck, var. **basalis**, n. var. Plate 15, figs. 4, 5

The *Astralium brevispinum* Lamarck is a recent species found living along the north coast of Panama and Costa Rica. It is most easily distinguished from the West Indian *A. longispinum* Lamarck by having its columellar area brilliantly stained with scarlet.

From upper Old Man Sam Creek in eastern Costa Rica, we collected a single specimen of an *Astralium*, very similiar in most of its characters to *brevispinum*. It differs most importantly in having a more strongly sculptured base. This sculpture consists of a wide, flat band, inside of which are 3, heavy, nearly equal spiral cords. The whole surface is crossed by squamose lines of growth.

Height 20, diameter 29.50 mm.

Gatun Stage: Coll. 6, Old Man Sam Creek.

Astralium caelatum Gmelin, variety

Trochus cælatum Gmelin 1792, Syst. Nat., p. 3581.

Astralium cælatum Pilsbry, 1888, Manual of Conch., first ser., vol. 10, p. 224, pl. 57, figs. 45, 46.

A large Turboid shell related to the recent *A. cælatum* Gmelin was collected from the coral limestones near Port Limon. It is so firmly imbedded in its rocky matrix that only a small portion of its surface is exposed to view. Its surface sculpture is like that of *cælatum*, but the radial costæ on the upper part of its whorl are closely spaced and not far apart as in the recent shell. Its height measures 55 mm, diameter 54.

Gatun Stage: Port Limon.

Genus **CHLOROSTOMA** Swainson

Subgenus **NEOMPHALIUS** Fischer

Chlorostoma costaricensis, n. sp. Plate 15, figure 16

Shell conoidal, solid, with a narrow, but deep umbilicus; suture distinct; the last whorl is strongly carinate or angled below; above this angle, the whorl is evenly convex, below, the base is nearly flat; the sculpture consists of beaded spiral cords, there being on the last whorl above the angled periphery 7 or 8 cords; the interspaces are nearly as wide as the cords, and are finely etched by oblique lines of growth and finer spirals; on the base, the spirals are irregular, the strongest about the middle; there are 2 or 3 cords about the upper part of the umbilicus, but the interior wall is smooth.

Height 10.5, diameter 16.5 mm.

The transitional beds between the Uscari and the Gatun of Red Cliff Creek, contain in addition to the usual fauna, several species, as certain Cerithoids, *Sistrum nodulosum*, *Modulus modulus*, *Nitidella* and the present species, whose normal habitat is on the rocks and reefs of the extreme, upper limit of the littoral zone. They are always much broken and worn as if they had been rolled and washed about by the surf on a rocky or sandy beach and then drifted out to the deeper and quiter waters off shore where depostion was going on.

Although all of our specimens of *C. costaricensis* are very fragmentary and much worn, we have deemed it best to place the species on record, as this subgenus has been recorded only very doubtefully from beds older than the Pleistocene.

Uscari Stage: Zone 6, Red Cliff Creek.
Gatun Stage: Zone 5, Red Cliff Creek.

Genus **CALLIOSTOMA** Swainson

Calliostoma limonensis, n. sp. Plate 15, figures 8, 11

Shell of medium size, conic; whorls about 8, flat or but slightly convex, so that the profile of the shell is a broad cone; sutures indistinct; the whorls are closely sculptured with fine, beaded spirals of primary and secondary orders; each spire-whorl has 7 or 8 primary spirals alternating with 1, 2 or 3 secondary; periphery sub-angular; base but slightly convex and closely spiralled with flat or sub-obsoletely beaded spirals (about 20), umbilicus narrow but deep, smooth within.

Height 19, diameter 18.5 mm.

Fairly abundant in the coral limestones along the shore west of Port Limon. Related to the recent *C. jujubinum* Gmelin, it differs by its more globose form and small, pointed attenuated apex.

Gabb has also described a small *Calliostoma* from the Limon Peninsular, as *C. Guppyana*. This shell of 8 or 9 whorls measures but 5 mm in height. It is a higher and more conic form with the whorls sculptured with beaded spirals.

Gatun Stage: Port Limon.

Calliostoma mancinella, n. sp. Plate 15, figures 9, 10

Shell of medium size; whorls about 8, with very indistinct sutures and a coarse sculpture of beaded spirals; the spire whorls are flat sloping evenly from the small projecting nucleus to the broadly rounded periphery of the last whorl; sculpture of the spire-whorls consists of about 6, strongly beaded spirals the largest of which bounds the upper sutures; between these spirals are scattered a few smaller ones, the lower half of the periphery and the base have about 12 additional spirals; these spirals are larger, more widely spaced and are smooth except the 4 or 5 around the umbilicus; the interspaces of the basal spirals are finely incised by minute longitudinal lines, corresponding to the growth lines; umbilicus narrow, but deep,

smooth within; aperture rounded, with the outer lip strongly oblique.

Height 15, diameter 21 mm.

Several specimens of this well-marked species were obtained from the Gatun beds of eastern Costa Rica, in the vicinity of Manzanilla Point. In the Santo Dominican Miocene it is related to the *C. Grabaui* Maury, but the Costa Rican shell is much lower and more depressed.

The *C. Grabaui* and the *mancinella* belong to the group which contains the large, elegant *C. Sayana*, described by Dall from deep water off the Hatteras coast.

Gatun Stage: Coll. 4, East Grape Point Creek.
Headwaters of Middle Creek.
Coll. 5, Red Cliff Creek.
1 mile south of shore, along Old Man Sam Creek, (Veatch)

Calliostoma castilla, n. sp. Plate 15, figure 6, 7

Shell rather large, in form and sculpture resembling the *C. philanthropus* of the Chesapeake Miocene of eastern United States, but umbilicated; whorls 5 plus (apex broken), flat and forming a broadly conic spire; periphery of the last whorl, subangular, due to a broad, cord-like ridge, which appears as if formed form an overlapping of the base; sculpture of the spire-whorls of fine, alternating and beaded spirals, there being about 13 on each whorl; the base is nearly smooth the spirals being nearly obsolete or as broad low bands; the spirals about the umbilicus are slightly stronger and obscurely beaded; umbilicus deep and narrow.

Height 20, diameter 25 mm.

A large species with an angulated periphery, fine, beaded spirals above and a nearly smooth base. But a single specimen

was collected from the coral limestones near Port Limon, associated with the common *limonensis*.

Gatun Stage; Port Limon.

CLASS SCAPHOPODA

Genus **DENTALIUM** Linnæus

Subgenus **DENTALIUM**, s. s.

Dentalium bocasensis, n. sp. Plate 15, figures 2, 3

Shell rather larger, solid, gently curved and increasing gradually in size; the tip is more curved than the rest of the shell and strongly hexagonal in cross-section; the sculpture consists at first of 6 strong, primary ribs and wide, flat or slightly concave interspaces; the ribs are further increased by the introduction of 6 intermediate ribs and still later by 12 more; these ribs are subequal in size on the later portions of the shell; the interspaces are finely transversely lined and faintly longitudinally striated.

Length 52, diameter 6.25 mm.
44, 4.75 mm.

The *Dentalium bocasensis* is fairly abundant in the shale beds of Bocas Island. It is recognized by its strongly hexagonal tip and finely transversely lined interspaces, and strong longitudinal sculpture.

Gatun Stage: Bocas del Toro.

Subgenus **FISSIDENTALIUM** Fischer

Dentalium uscarianum, n. sp. Plate 15, figure 1

Shell large, solid and heavy; gently curved, and the taper of the shell is slow and gradual; the tips are all broken on our specimens, but the later sections of the shell are circular or slightly compressed dorsal-ventrally; the surface is sculptured with about 24, low, subregular and rounded longitudinal ribs with

smaller intermediate ones in the interspaces; the ribs become gradually obsolete with age and the later portions of full-grown shells are nearly smooth; fine transverse lines of growth cross the surface and are best seen on the earlier portions of the shell; operture oblique.

Length 60, diameter 12 mm.

This large *Dentalium* is abundant and very characteristic of certain conglomeritic zones in the Upper Uscari shales. There it occurs associated with a small but very distinctive fauna, including the *Ptychosalpinx*? *dentalis*, *Sconsia cocleana* and *Scaphella costaricana* and other species. When complete, the *Dentalium uscarianum* frequently reached a length of 110 mm or more.

All our specimens are unfortunately lacking in the apical tip. In general sculpture, it recalls the *Dentalium floridense* Henderson dredged from 35 to 110 fathoms of water off Florida and in the West Indies, but the taper of the shell is more gradual and the sculpture more irregular, becoming obsolete with age. Bose* has described a large species as *Dentalium rimosum* from the Miocene of the Tehuantepec Peninsula. In that species, the ribs number about 31, are very regular with deep interspaces, and ribs are finely etched by transverse lines of growth.

Uscari Stage: Coco Plum, Panama.
Rio Cocles.
Margarita—Old Harber trail.
Comadre Creek.
Pumbri Creek, etc.

*Boll. Inst. Geol. do Mexico, No. 22, p. 55, pl. 3, figure 1, 1906.